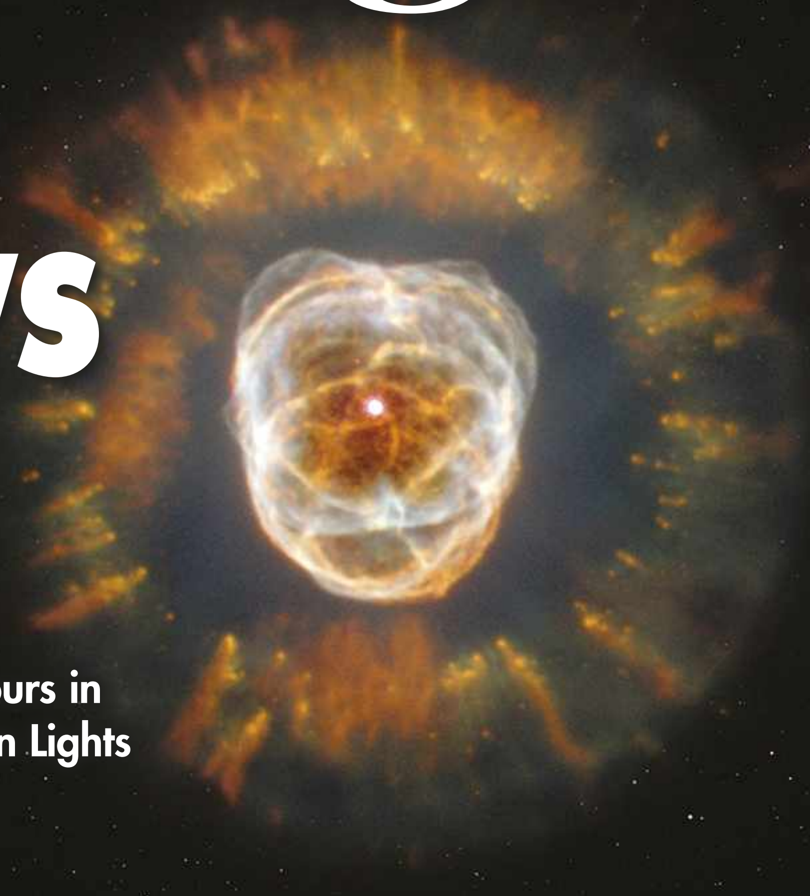
BBC

NASA PROBE NEARS THE MYSTERIOUS WORLD CERES

THE BIGGEST NAME IN ASTRONOMY

Sky at Night



IMPROVE YOUR DEEP-SKY VIEWS

Train your eyes to unlock hidden detail in the distant gems of deep space

CAPTURE THE SPIRIT OF THE FAR NORTH

High latitude photo tours in search of the Northern Lights

JUPITER AT OPPOSITION AND MORE

Our pick of this month's best night-sky sights

COLOURING THE SUN

Expert guidance on processing solar images

ALSO IN THIS ISSUE

1ST FOR GEAR

Easier mono imaging: the new Atik CCD with in-built filter wheel

CUT OUT CURRENTS

6 cost-effective ways to keep your scope cooler for longer

TRIAL BY FIRE

Europe's new spaceplane undergoes its toughest test yet

FEBRUARY 2015 #117
www.skyatnightmagazine.com

Welcome

Jupiter comes to opposition as Dawn closes in on Ceres

This month's contributors include...

MARTIN LEWIS
OBSERVING EXPERT

Martin reveals the tested methods he uses to see faint details in deep-sky objects. *Page 36*

GOVERT SCHILLING
ASTRONOMY AUTHOR

Govert previews the arrival of NASA's Dawn probe at Ceres, in what will be our first close-up with a dwarf planet. *Page 42*

PAUL ABEL
PRO ASTRONOMER

Paul's *Visual Observing Guide* continues with a look at how you can track the waxing and waning of variable stars. *Page 73*

GARY PALMER
SOLAR IMAGER

In the second of our image processing columns, Gary explains how to colourise a mono image of the Sun. *Page 85*

There are those among us who look back wistfully as the Christmas decorations go back in the attic, while others look forward to having more time to explore the night skies in this season of long nights. Which is just as well as there is plenty in the celestial sphere to occupy our time this month, including the opposition of mighty Jupiter on the 6th. Observing it with large telescopes is always rewarding, and this month there's the added attraction of the continued interactions between the gas giant's Galilean moons. For this, and top sights with smaller scopes, binoculars and the naked-eye, turn to the *Sky Guide* on page 47.

When you can slew away from such a transfixing sight, we have the techniques you need to get the most out of observing the treasures of the deep-sky on page 36, where we explain how to maximise the acuity of your visual system.

And relevant for both deep-sky and planetary observing is the practical advice you'll find on page 81. Here we detail how to banish the effects of those troublesome tube currents caused by moving air set off by temperature differences, which can play havoc with the stillness of views, whether at the eyepiece or on the imaging chip.

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There's a lot to look forward to from professional astronomers and space engineers in 2015 too. ESA tests its new spaceplane (see page 62) and we look at the Dawn mission's arrival at Ceres on page 42. The NASA probe will soon enter orbit around a dwarf planet that's similar in size to the US state of Texas.

Enjoy the issue!

Chris Bramley Editor

PS Next issue goes on sale 19 February.

Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...

TELEVISION
Find out what *The Sky at Night* team will be exploring in this month's episode on page 17

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In the magazine

NEW TO ASTRONOMY?
See *The guide* on page 78 and our online glossary at www.skyatnightmagazine.com/dictionary


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Ⓒ = on the cover


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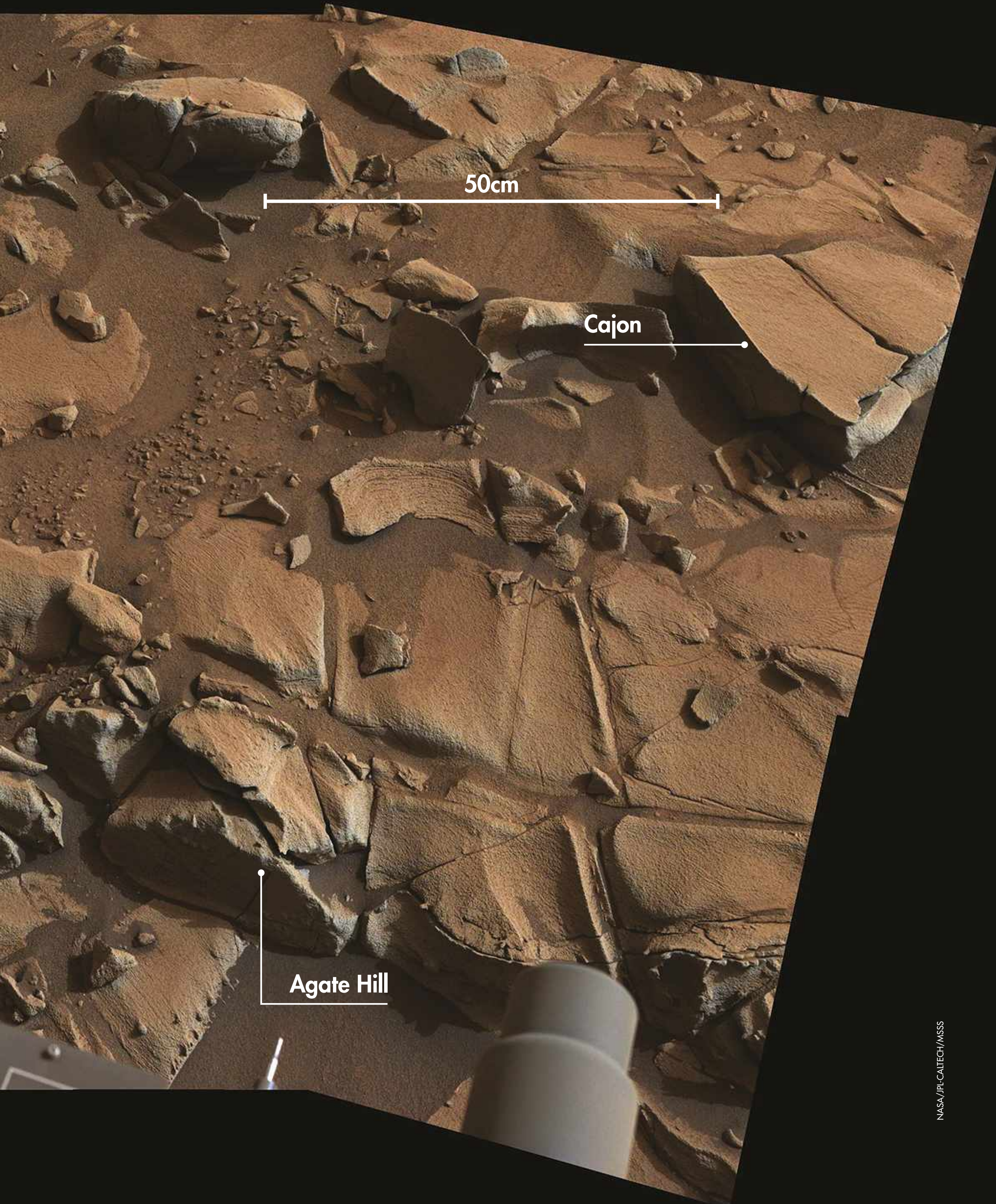
Block party

Curiosity Rover, 23 November 2014

The distant explorer prepares to get up close to a trio of Martian sample sites

With crisp resolution, intricate detail and white balancing to replicate how the scene might appear on Earth, this image from NASA's Curiosity Rover is one of the most fascinating yet. Curiosity's Mast Camera captured this area of bedrock, nicknamed Alexander Hills, as it prepared to make a detailed study of the three annotated targets: Aztec, Cajon and Agate Hill.

The photo was created from a mosaic of six images and covers an area around 2m across. In 2013, Curiosity became the first rover to drill into and sample Martian bedrock, giving scientists back on Earth the most comprehensive evidence to date for Mars's watery past.



NASA/JPL-CALTECH/MSSS

▲ Realising Europa

GALILEO SPACECRAFT, 21 NOVEMBER 2014

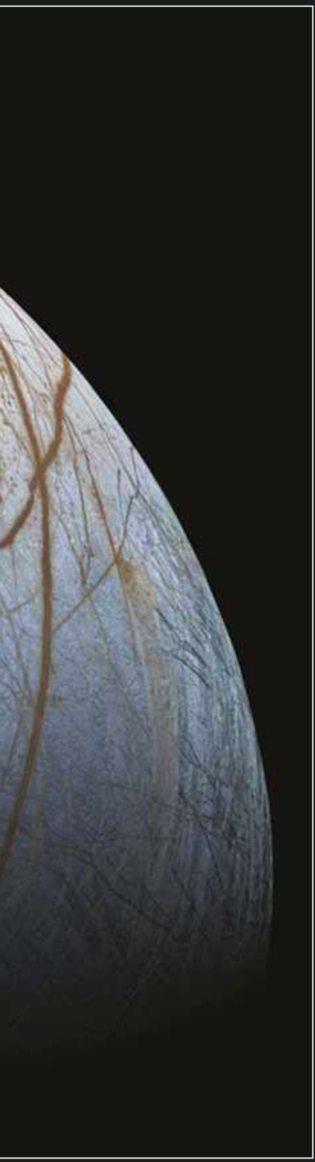
To many this image of Jupiter's icy moon Europa is familiar, having first been captured by NASA's Galileo probe in the late 1990s. But this new rendition has been carefully reprocessed to show how the moon would appear to human eyes. It reveals Europa's active geology: the long cracks are the result of movement in the moon's icy crust.

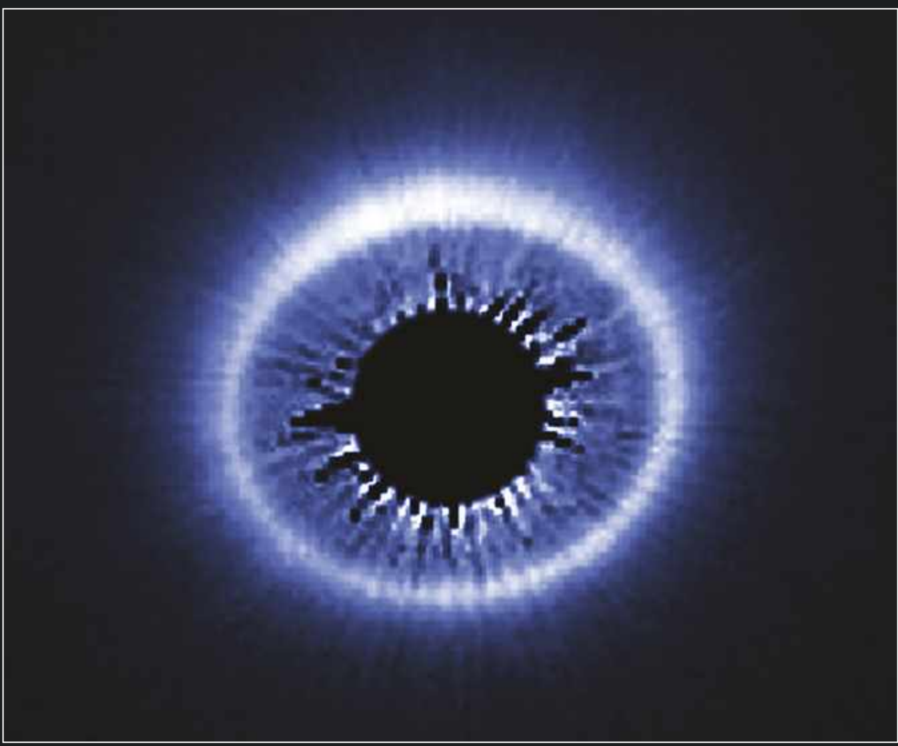
◀ Wandering stars

HUBBLE SPACE TELESCOPE 30 OCTOBER 2014

The false colour added to this image highlights the immense starlight given off by the stellar residents in the numerous galaxies of Abell 2744, Pandora's Cluster. The darker blue areas are the locations of long-dead galaxies, the light in these regions emanating from lone stars that are floating through the cluster but are not gravitationally linked to any of the surrounding star systems.

NASA/JPL-CALTECH/SETI INSTITUTE, NASA/ESA/G. SCHNEIDER (UNIVERSITY OF ARIZONA) AND THE HST/GO 12228 TEAM, NASA/ESA/M. MONTES (IAC) AND J. LOTZ/M. MOUNTAIN/A. KOEKEMOER AND THE HFF TEAM (STSCI), ESO/VVV TEAM/A. GUZMÁN





▲ Beyond the stars

EUROPEAN SOUTHERN OBSERVATORY
1 DECEMBER 2014

Amid this stellar canvas of the Milky Way within Scorpius is a dense orange cloud, and right at its heart is a very young star 15 times more massive than our Sun. Astronomers have observed this star drawing material in from its surroundings, contrary to all previous theories that would expect its powerful radiation to push material away.

◀ Discovering diversity

HUBBLE SPACE TELESCOPE
6 NOVEMBER 2014

This image of the circumstellar disc around the distant star HD 181327 was captured as part of a Hubble survey to identify the diversity in the formation of exoplanetary systems. The survey revealed that the circumstellar discs vary dramatically and don't all resemble the flat and even structures of classical theories.

Bulletin

The latest astronomy and space news written by **Hazel Muir**

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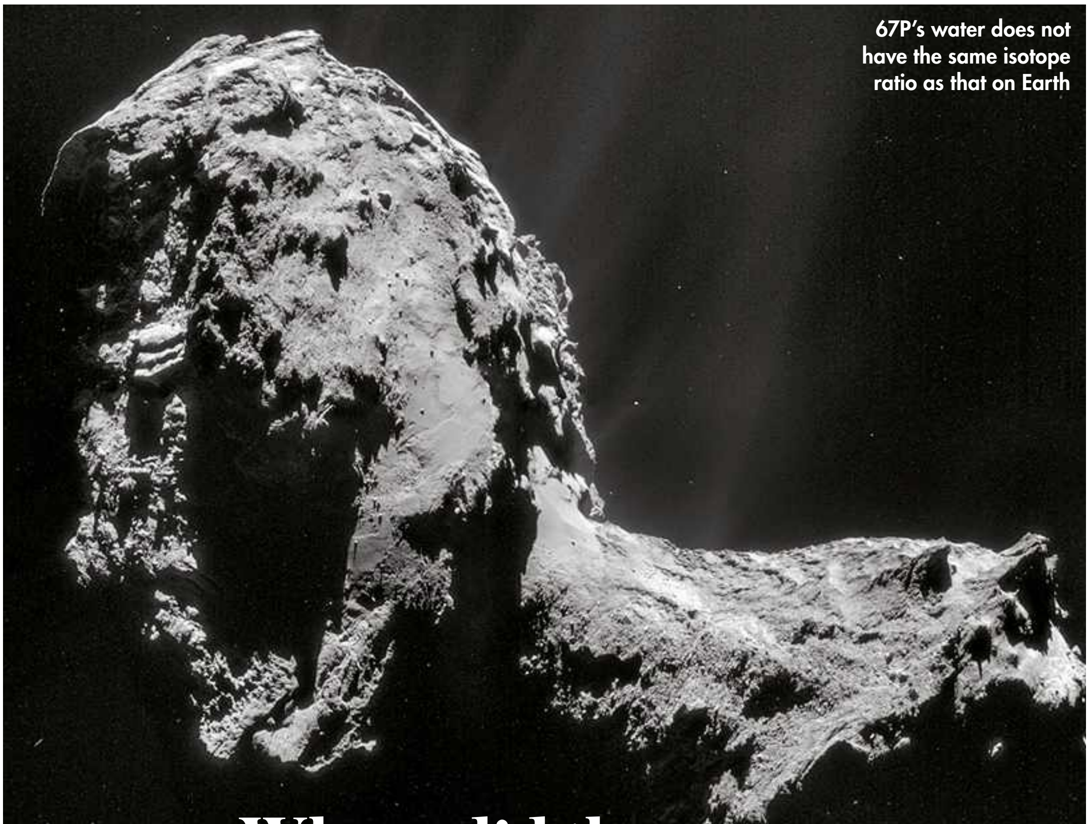
Our experts examine the hottest new astronomy research papers



67P's water does not have the same isotope ratio as that on Earth

Where did the Earth's oceans come from?

European probe sheds light on the source of Earth's water

ESA'S ROSETTA SPACECRAFT has challenged current thinking about the origins of water on Earth. It has shown that the make-up of comet water is often different to that on Earth, hinting that asteroids, rather than comets, were the major source of Earth's oceans.

Scientists believe that when the Earth formed 4.6 billion years ago, it was so hot that its water boiled off. But today our planet has vast oceans, so where did all this water come from? The likely sources are comets and asteroids that hit Earth after it cooled. However, their relative contribution to our planet's water supply is still unclear.

Rosetta, which arrived at Comet 67P/Churyumov-Gerasimenko last August, has added some clarity. It measured a key feature of the comet's water: its ratio of deuterium – an isotope of hydrogen with an extra neutron – to normal hydrogen. The ratio turns out to be more than three times higher than that of Earth's oceans.

Scientists conclude that asteroids, rather than comets, probably delivered most of our water. Rocky bodies in the asteroid belt between Mars and Jupiter have similar water composition to that on Earth.

"As Rosetta follows the comet on its orbit around the Sun throughout next year, we'll be keeping a close watch on how it evolves and behaves," says Matt Taylor, ESA's Rosetta project scientist. "This will give us unique insight into the mysterious world of comets and their contribution to our understanding of the evolution of the Solar System."

► See Comment, right

COMMENT

by Chris Lintott

Asteroids may well be the source of Earth's water, yet I'm beginning to have second thoughts.

It is becoming clear that the early Solar System's small bodies have had a complex and interesting history; and it is certainly true that, back in the early history of the Solar System, there was a period in which the sheer number of asteroids hitting Earth might have been high enough to make this explanation fit. What I can't see is how Earth's water could have been delivered by asteroids without being diluted by an equal influx of comets, altering the deuterium to hydrogen ratio again.

Instead, we should probably look towards Earthly solutions. Geologists have recently suggested that rocks deep in the Earth's mantle may have provided a refuge for water, which would then be released when plate tectonics carried them up to the surface. Rosetta may have travelled six billion miles to tell us to look closer to home.

CHRIS LINTOTT co-presents *The Sky at Night*

Dawn spacecraft meets Ceres

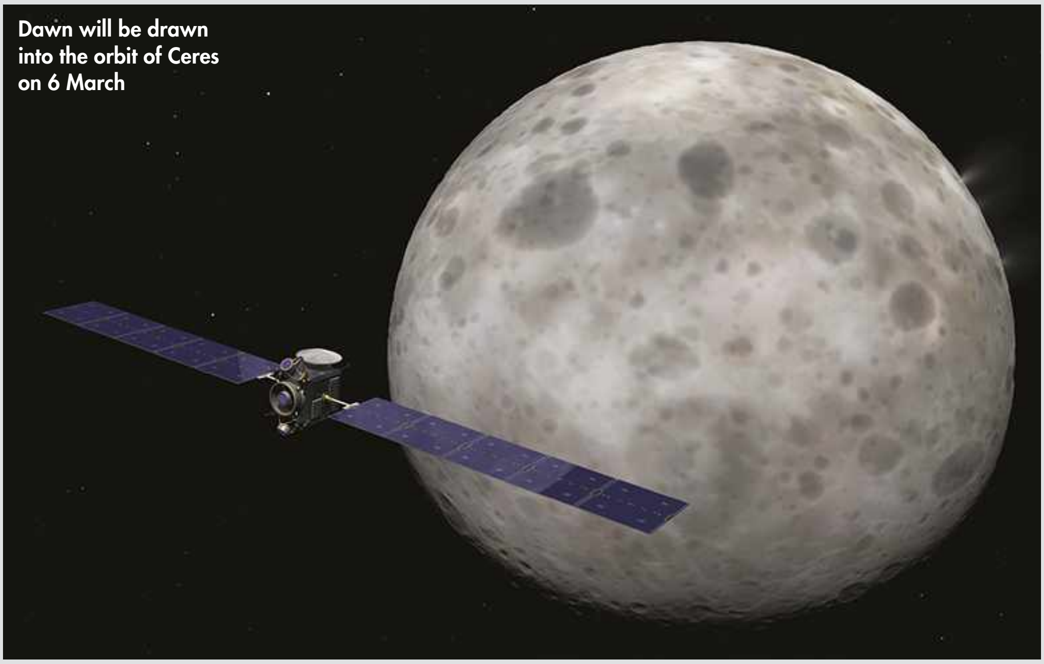
For the first time, a probe will encounter a dwarf planet

NASA's Dawn spacecraft is due to be captured by Ceres, the largest body in the asteroid belt between Mars and Jupiter, in March to April 2015.

Ceres is roughly 950km wide and has an icy mantle surrounding a rocky core. "Finally, we have a spacecraft on the verge of unveiling this mysterious alien world," says mission director Marc Rayman from NASA's Jet Propulsion Laboratory in California. "Soon it will reveal the many secrets Ceres has held since the dawn of the Solar System."

Since launching in 2007, Dawn has already visited the asteroid Vesta, granting us an unprecedented look at its cratered surface and clues about its geological history. Scientists expect that by learning about these bodies and how they formed, we will gain a better understanding about the origins of the terrestrial worlds of our Solar System. **www.nasa.gov/dawn**

▶ **Turn to page 42 for our in-depth feature on the Dawn mission to Ceres**



Dawn will be drawn into the orbit of Ceres on 6 March

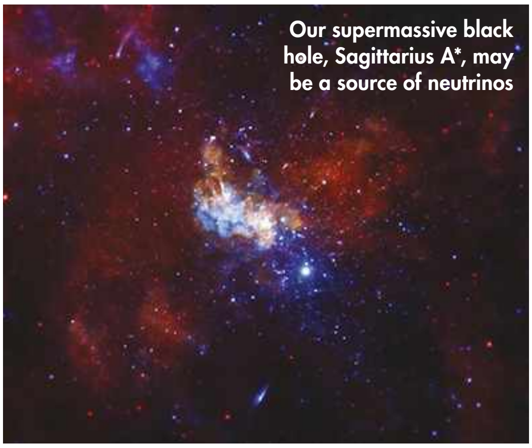
BLACK HOLES MAY BE NEUTRINO FACTORIES

THE MONSTER BLACK hole at the heart of our Galaxy sends out ghostly particles called neutrinos, a new study suggests. If confirmed, this would be the first time neutrinos have been traced to a black hole source.

Neutrinos are lightweight particles that move at close to the speed of light. Some are generated by nuclear reactions in stars, but the origins of neutrinos with especially high energy have puzzled astronomers.

"Figuring out where high-energy neutrinos come from is one of the biggest problems in astrophysics," says Yang Bai from the University of Wisconsin in Madison.

A neutrino detector at the South Pole has detected several dozen neutrinos with extremely high energies since 2010. Now Bai's team has matched some of these events to outbursts from the black hole at the Milky Way's centre, recorded by NASA satellites including the Chandra X-ray Observatory.



Our supermassive black hole, Sagittarius A*, may be a source of neutrinos

The black hole triggers explosive eruptions when clouds of gas and dust fall towards it, but exactly why these flare-ups generate neutrinos – recorded just hours later – remains unclear. **www.nasa.gov/chandra**

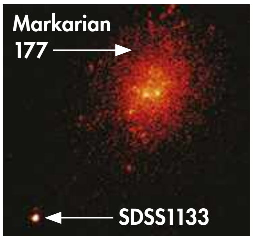
NEWS IN BRIEF

EVICTED BLACK HOLE DISCOVERED

Scientists have discovered a curious object that may be a supermassive black hole that has been ejected from its home galaxy following a merger. However, it is also possible that the light source may be a star in the run up to an unusual supernova explosion.

The object, SDSS1133 is part of dwarf galaxy Markarian 177, resting 2,600 lightyears from its core.

"We suspect we're seeing the aftermath of a merger of two small galaxies," says team member Laura Blecha from the University of Maryland. "Finding one of these recoiling black holes would be a major discovery."



ORION TEST IS FLYING SUCCESS

In December, NASA hailed a major milestone for the Orion spacecraft as it completed its first voyage into space. During the uncrewed test, it travelled farther than any other spacecraft designed for astronauts in more than 40 years.

The crew module later splashed down in the Pacific Ocean. "The flight test is a huge step for NASA and a really critical part of our work to pioneer deep space on our journey to Mars," says NASA Administrator Charles Bolden.

NEWS IN BRIEF

NEW HORIZONS AWAKES

Pluto-bound spacecraft New Horizons awoke from hibernation in December after a journey that has lasted more than nine years. Since launching in 2006, the probe has spent about two-thirds of its time in largely unpowered hibernation to reduce wear and tear on its components.

"This is a watershed event that signals the end of New Horizons' crossing of a vast ocean of space to the very frontier of our Solar System," says Alan Stern from Southwest Research Institute in Colorado, lead scientist for the mission. The spacecraft's closest approach to Pluto will occur on 14 July.

GREEN LIGHT FOR GIANT TELESCOPE

Construction of the 39m European Extremely Large Telescope (E-ELT) in Chile has been given the official go ahead. It means contracts for the construction will be agreed this year.

"The telescope will enable discoveries at all scales of the Universe, from measurements of life-marker gases in the atmospheres of exoplanets to understanding the birth and evolution of stars and galaxies," says Colin Cunningham, UK programme director for the project.

NASA/JPL-CALTECH/MSSS X 2, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE (JHUAPL/SWRI)

New hints of life on Mars

Odd spikes in methane on the planet are raising suspicions

STRANGELY HIGH SPIKES in levels of methane in the Martian atmosphere have been measured by NASA's Curiosity rover. Some scientists have speculated that this might be a sign of current life on the planet, as microbes on Earth release methane as part of their digestion process. But there are several other possible reasons for the gas changes.

"This temporary increase in methane – sharply up and then back down – tells us there must be some relatively localised source," says mission scientist Sushil Atreya from the University of Michigan in Ann Arbor. "There are many possible sources, biological or non-biological, such as interaction of water and rock."

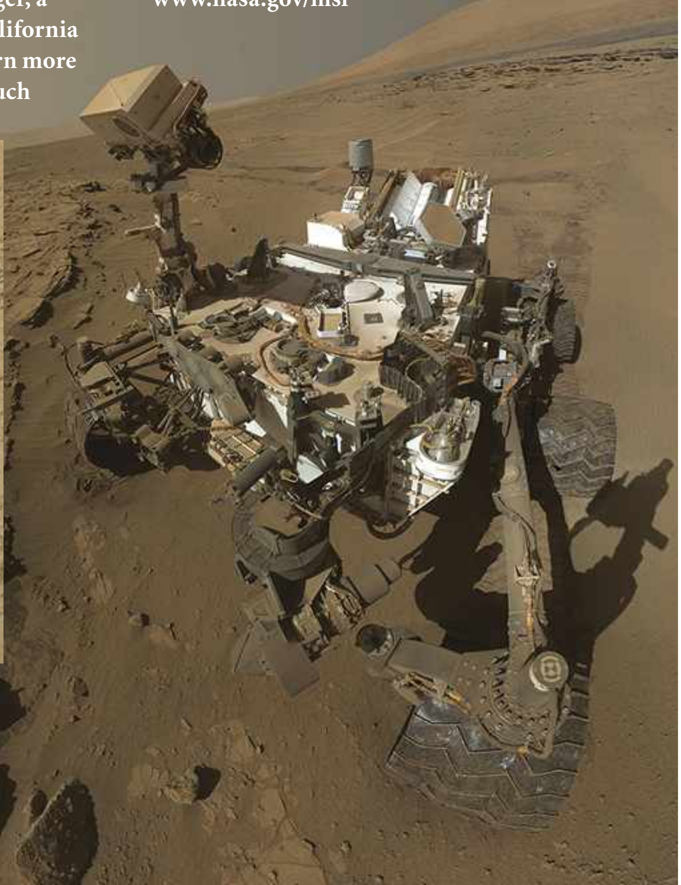
In late 2013 and early 2014, four measurements of methane by Curiosity averaged seven parts per billion. Before and after that, readings averaged only a tenth of that level. The reason for the sudden increase is not known, but organic molecules containing carbon, and usually hydrogen, are the chemical building blocks of life.

"We will keep working on the puzzles these findings present," says John Grotzinger, a Curiosity rover scientist from the California Institute of Technology. "Can we learn more about the active chemistry causing such fluctuations in the amount of methane in the atmosphere? Can we choose rock targets where identifiable organics have been preserved?"

Apart from microbes, another possible source of the methane are clathrates, ice in which methane gas is trapped. Some kind of trigger could destabilise the clathrates, allowing methane to seep up through fissures in Martian rocks and enter the atmosphere.

In other experiments, Curiosity has found organic chemicals in powder drilled from a rock dubbed 'Cumberland'. These could have formed on Mars or been delivered by meteorites. Although Curiosity's intriguing discoveries don't say anything definitive about whether Mars has ever harboured life, they highlight vigorous chemical activity on the planet and suggest life isn't out of the question.

"This first confirmation of organic carbon in a rock on Mars holds much promise," says Curiosity scientist Roger Summons from the Massachusetts Institute of Technology. He hopes the rover will find further rocks on Mars that have different and even more diverse organic compounds.
www.nasa.gov/msl



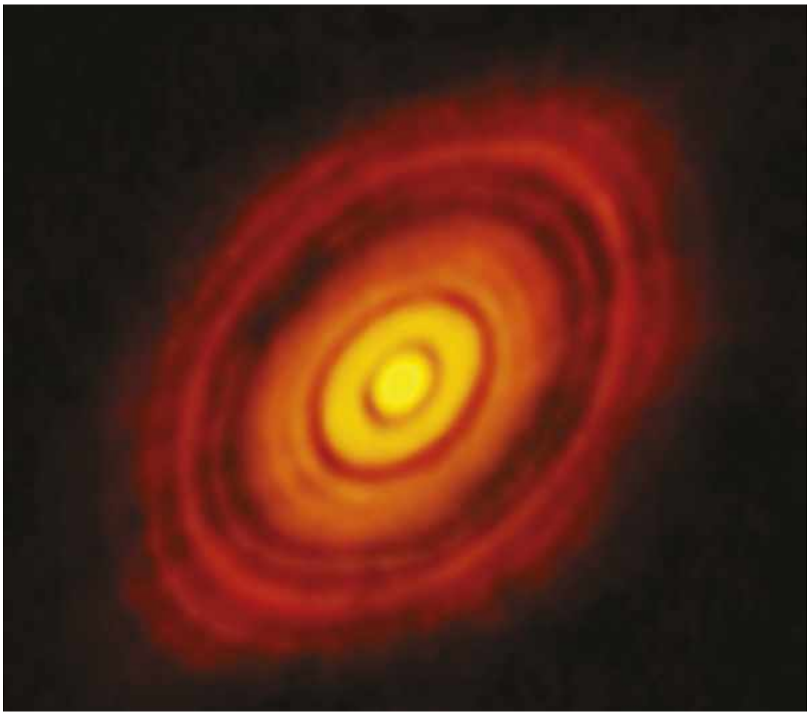
▲ Curiosity found organic compounds after drilling into a rock dubbed 'Cumberland' in May 2013

CUTTING EDGE

Our experts examine the hottest new research

Sculpting star systems

New simulations could explain how planets form from discs of dust swirling around young stars



HL Tauri and its protoplanetary disc are found in the Taurus Molecular Cloud 1, the star-forming region nearest Earth

ALMA (ESO/NAOJ/NRAO)

This recently released image from ALMA of rings in the protoplanetary disc around HL Tauri is an instant classic, a snapshot of planet formation in action. And now a paper from a Zurich-led European team may be able to explain exactly how structures like these come about.

A lot of the excitement around the image is because the presence of rings and gaps seems to indicate that there are planets forming in the disc. Structure in the rings of Saturn is often due to the gravitational influence of its moons, and newly formed planets could play the same role here. The problem is that simulations which shed light on the behaviour of gas in a planet-forming disc had suggested that although rings such as these could form, they would be very short lived.

To get them to last longer than a hundred or so planet orbits – more than a few hundred years – has been tricky, but it's this problem that the authors have addressed. It turns out that the presence of dust in the disc, not just gas, is critical. Dust – the word astronomers use for the tiny particles of silicon and graphite, each no bigger than a sand grain – has been the solution to many an astronomical mystery over the years and, given that it is the material from which planets begin forming, it is no surprise that it is important here.

The result depends on the performance of simulations of a disc similar to one our own Solar System may have formed from. One or two planets are introduced into the disc, and gaps quickly open up as a result of their interaction with the dust. It's then that the magic happens – the change in the distribution of gas allows particles of dust to start collecting. The really exciting thing about the physics of this is that no matter what the conditions – whatever the gas is doing or whether there is one planet stirring things up or two – there is always some size of dust grain that gets preferentially trapped.

For the kind of disc we think may have formed our Solar System it's larger particles, with diameters of millimetres or centimetres, that begin to clump together. Then, as the gas begins to dissipate, this collection of particles stays together as a long-lived dust ring from which planets can then, presumably, form. If this happens often, we should expect systems where a smaller planet, formed from the dust ring, should sit between two larger worlds. Such arrangements have indeed been found by Kepler, much to my surprise and confusion, but these simulations offer a natural explanation.

> "It turns out that the presence of dust in the disc, not just gas, is critical"

The authors resist the temptation to declare the case closed, however. Lots more work will be necessary to identify the circumstances in which this promising mechanism can operate. The main loophole to be closed is, I think, that the planets on either side of the ring were held in the same orbits throughout the simulation, whereas we know migration is common. Yet it seems to me an important part of a complex picture, and another stepping stone to understanding why the Galaxy contains such a remarkable diversity of worlds.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading… *Long-lasting dust rings in gas-rich disks: sculpting by single and multiple planets* by Farzana Meru et al

Read it online at http://arxiv.org/abs/1411.5366

NEWS IN BRIEF

STRANGE GALAXY POSES PUZZLE

A rare type of galaxy that could clarify how such structures developed in the early Universe has been found with the help of the Galaxy Zoo citizen science project.

The galaxy is around 800 million lightyears from Earth and is a spiral like our own Milky Way. However, it has very large jets of subatomic particles streaming out from its core, an unusual feature for spiral galaxies.

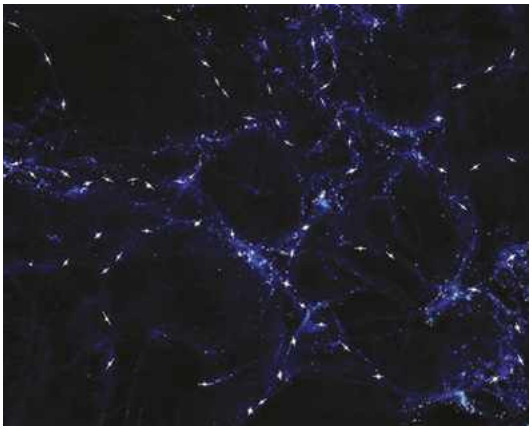
"This galaxy presents us with many mysteries," says team member Minnie Mao from the National Radio Astronomy Observatory in New Mexico. "We want to know how it became such a strange beast."

JAPAN LAUNCHES ASTEROID MISSION

Japan successfully launched its Hayabusa 2 probe in December 2014. Its goal is to survey an asteroid called 1999 JU3, using an explosive device to dig up the asteroid's surface for fresh sample material to return to Earth in 2020.

Quasars show spooky alignment

The unexpected finding challenges current cosmic theories



▲ **Quasars (white) inhabit large-scale cosmic structures (blue); the lines show the spin axes of their black holes**

USING THE VERY Large Telescope in Chile, astronomers have noticed a strange alignment of quasars across billions of lightyears: the rotation axes of their supermassive black holes are often parallel.

Quasars are energetic galaxies with supermassive black holes at their centres and they often spew out jets of particles along their axes of rotation. A new study shows their rotation axes tend to be aligned with the large-scale filaments of cosmic material they inhabit, and the chance this is mere coincidence is less than one per cent.

"There is a missing ingredient in our current models of the cosmos," says team member Dominique Sluse from the University of Bonn, Germany.

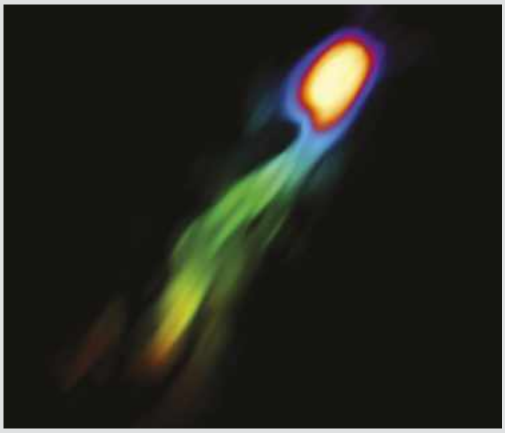
www.eso.org/vlt

HOW A GALAXY SELF-DESTRUCTS

A DRAMATIC 'BLOW OUT' phase of galactic evolution has been discovered using a radio telescope in the French Alps. James Geach from the University of Hertfordshire and colleagues found dense gas being blasted out of a galaxy called SDSS J0905+57 at several million kilometres per hour. The gas is driven to vast distances by intense pressure from the radiation of extremely rapid star formation.

The gas removal will quickly halt the star formation boom. "We are witnessing the aggressive termination of star formation, and the mechanism by which this is happening is an important new clue in our understanding of galaxy evolution," says Geach.

www.herts.ac.uk



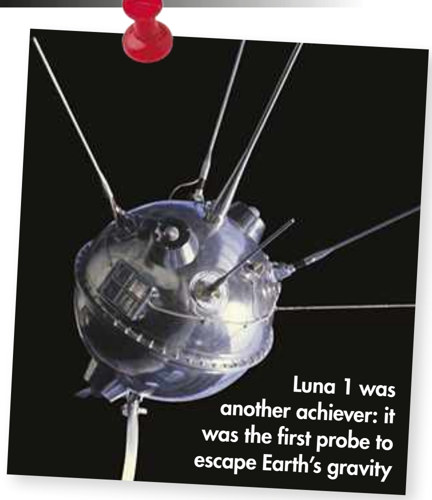
The loss of such a large amount of gas is likely to have a major impact on a galaxy's evolution

Looking back The Sky at Night

February 1971

On 3 February 1971, *The Sky at Night* broadcast discussed Soviet and American space achievements, which had been stacking up at an incredible rate. Since the Soviet Union launched the first satellite (Sputnik 1) in 1957, the US had pulled out all the stops to get astronauts to the Moon. They did this in an extraordinarily short time – the US went from having effectively no space programme to putting men on the Moon in just a decade.

The crewed US Apollo missions returned lunar rocks that radically changed scientific thinking about the history of the Solar System. But they were not the only missions to collect lunar samples. The Soviet Union's Luna project collected and returned several samples of lunar soil to Earth by 1970, a challenge that was amazingly complicated with contemporary technology and would still be daunting even today.



Luna 1 was another achiever: it was the first probe to escape Earth's gravity

CUTTING EDGE

Our experts examine the hottest new research

Earth's many minimoons

Asteroids captured by Earth could be future test sites for the mining of space minerals

ISTOCK

▲ **Small asteroids regularly go into orbit around our planet, even if only briefly**

How many natural satellites does the Earth have? There is the Moon, of course, but actually at any one time there are also a number of small asteroids in orbit around the Earth, albeit only for a short time. The first of these temporarily captured orbiters (TCOs) or 'minimoons' was discovered in 2006. Each typically only sticks around for about nine months, before it is perturbed by gravitational interactions from the rest of the Solar System and drifts away again. Around one per cent, however, will end up on a collision course with the Earth and streak into our atmosphere as meteors.

As Bryce Bolin at the University of Hawaii and his colleagues argue, these temporary moons are extremely important: this population of nearby objects offers a perfect opportunity for studying asteroids to better understand the Solar System. And, since some of them end up as meteors, studying them would offer an unparalleled opportunity to measure the physical properties of meteoroids before their fiery entry into our atmosphere. TCOs are barely moving in relation to Earth and so would be relatively easy to reach – a space mission would require only a very low 'Delta-v' (a measure of the amount of energy required for orbital manoeuvres).

But despite their proximity, TCOs are actually very challenging to spot. The asteroids drift in and out of their captured orbit around the Earth and there aren't a great number of them at any one time. They mainly orbit about four times farther away than the Moon, and they're also pretty small – most are only a metre or two across, though it's calculated that about every 100,000 years, something up to 100m wide is temporarily captured by the Earth.

So what's the most effective way to find these minimoons in the first place? Bolin and his co-authors discuss how TCOs cluster mainly into the L1 and L2 Lagrangian points on the Earth-Sun line, where the gravitational tug of the Sun and Earth precisely balance so as to allow stable orbits with them. So a large, ground-based optical telescope could scan the L2 region opposite the Sun and catch minimoons in opposition, when they would appear brightest. Bolin picks out the US Department of Defense's Space Surveillance Telescope, which was built to detect and track satellites and orbital debris, as being ideally suited for surveying for TCOs. The Arecibo dish could also be used for radar sweeps. But perhaps the best approach would be to carry out a space-based infrared survey – spotting the soft glow of Sun-warmed asteroids. Bolin recommends an infrared observatory with a mirror around 1m across, to be located near the Earth-Sun L1 Lagrangian point.

> "TCOs are barely moving in relation to Earth, and so would be relatively easy to reach"

One of the biggest hopes for the future is to mine asteroids for metals and other valuable commodities, and TCOs would make perfect targets for missions to practise navigation and space rendezvous, or even retrieval missions. In this way, our temporary minimoons could serve as stepping stones to learning how to exploit space's resources.

LEWIS DARTNELL is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *Detecting Earth's temporarily-captured natural satellites – Minimoons* by Bryce Bolin et al

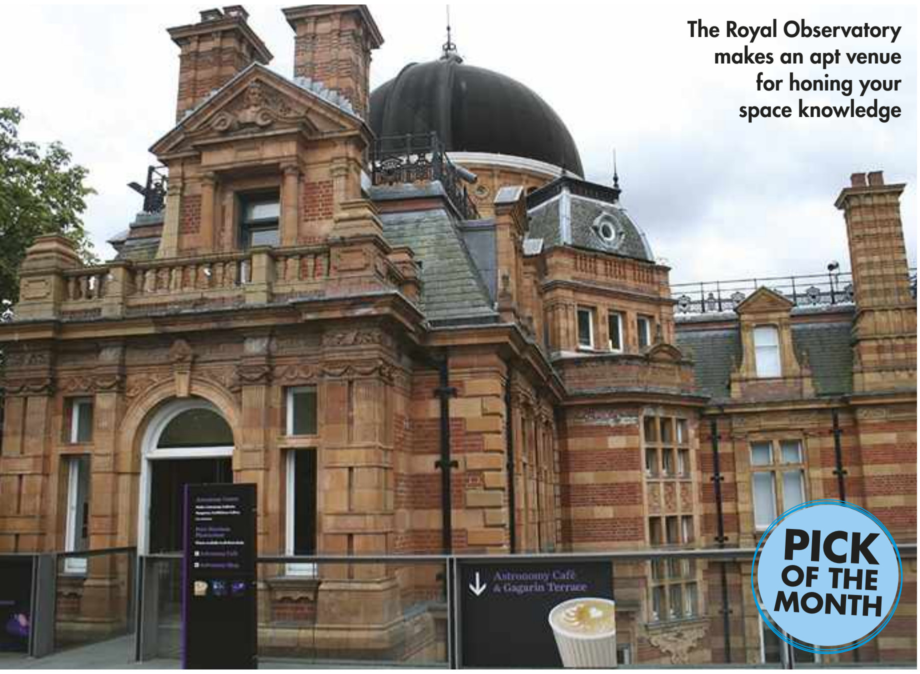
Read it online at www.sciencedirect.com/science/article/pii/S0019103514002796

What's on

Our pick of the best events from around the UK

Introduction to Astrophysics

Astronomy Centre, Royal Observatory Greenwich, Tuesdays at 7pm from 24 February to 24 March



The Royal Observatory makes an apt venue for honing your space knowledge

PICK OF THE MONTH

Are you a keen astronomer ready to further your knowledge of space science? The Royal Observatory Greenwich's introductory astrophysics course is a fantastic way to get you started in the subject.

The course runs for five weeks and will provide you with a basic understanding of astrophysics, with topics including the Solar System and the Milky Way, dark matter and dark energy, and cosmology and the Big Bang. Although no previous scientific knowledge is needed, this course is aimed at enthusiasts who already have a basic knowledge of astronomy.

The course costs £78 (£70.20 for members) and is split into five two-hour sessions, every Tuesday from 7pm. Visit the Royal Observatory Greenwich's website to book. **www.rmg.co.uk/whats-on/events/intro-astrophysics-2015**

BEHIND THE SCENES

THE SKY AT NIGHT IN FEBRUARY

BBC Four, **8 February**, 10pm (first repeat BBC Four, **12 February**, 7.30pm)*

UFOs are often claimed to be visiting aliens, but they commonly have terrestrial origins

WHAT HAVE UFOS DONE FOR US?

From unexplained flashes in the night sky to flying saucers, this month's episode delves into the mysterious world of UFOs – and how our drive to explain these bizarre phenomena, and to discover little green men, has in fact transformed our understanding of the Universe.

**Check www.bbc.co.uk/skyatnight for subsequent repeat times*

Astro Imaging

Torquay Boys' Grammar School, Torquay, 26 February 2015, 7.30pm

Steve Duncan talks through the basics of astro imaging at Torbay Astronomical Society this month. Find out how to take your hobby further and capture the amazing sights you see through the eyepiece. Tickets cost £3 for non-members. **www.torbayastro.org.uk**

Galaxies: Islands in the Sky

The Environmental Centre, Highfields School, Wolverhampton, 9 February 2015, 7.30pm

Join the Wolverhampton Astronomical Society this month and hear Dr Jacco Van Loon, lecturer on astrophysics at Keel University, discuss some of the other galaxies in the Universe. Tickets cost £2 for non-members. **http://wolvas.org.uk**

Dark Matter

JCR, Bristol Grammar School, 13 February 2015, 7.15pm

It is thought to make up almost 30 per cent of the Universe, but little is known of the mysterious substance known as dark matter. Andrew McLean visits Bristol Astronomical Society this month to explain why it is so important to our understanding of the cosmos. Entry for non-members is free if it's your first visit, otherwise £2. **www.bristolastrosoc.org.uk**

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

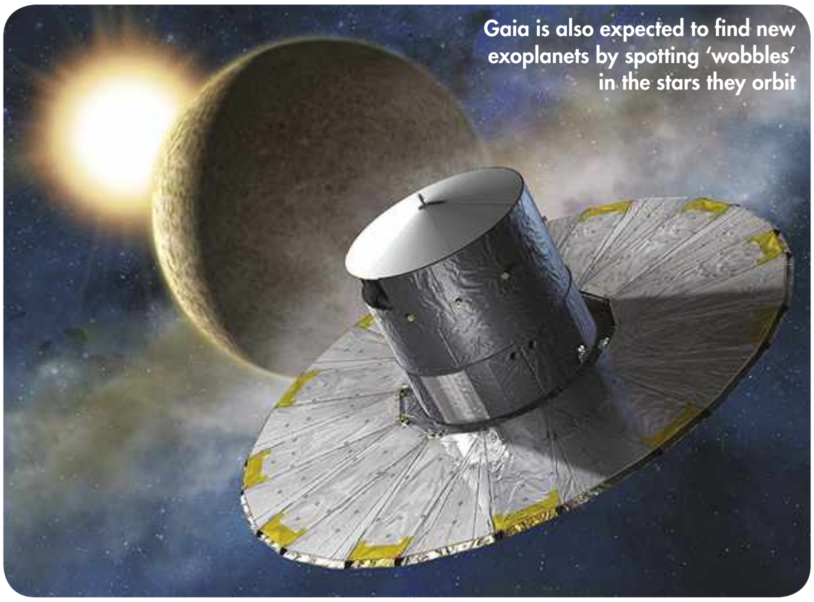
To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

ISTOCK X 2, NASA/ESA/CFHT/CXO/M.J. JEE (UNIVERSITY OF CALIFORNIA/DAVIS AND A. MAHDAVI (SAN FRANCISCO STATE UNIVERSITY)

A PASSION FOR SPACE

with **Maggie Aderin-Pocock**

The Sky at Night presenter considers how the Gaia mission will continue the age-old quest to map the stars



Gaia is also expected to find new exoplanets by spotting 'wobbles' in the stars they orbit

ESA–D. DUCROS 2013

Visiting e2v in Chelmsford is like going to see an old friend that I have not seen for many years. The company makes detectors for ground and space-based instrumentation across the world. My dealings with them occurred some 12 years ago, when they supplied two massive charge-coupled devices (CCDs) for the instrument that I was managing.

At the time, the detectors seemed colossal: two chips each 2,048 pixels wide and 4,608 pixels long – and they were quite cutting edge compared to what you would find in your average mobile phone or even a top of the range digital camera. But my detectors paled into insignificance when I met the mock-up to the Gaia array.

The real thing, launched just over a year ago, consists of 106 CCDs each 4,500 by 1,966 pixels, making an array of one billion pixels in total. But what is such a gargantuan array designed to do? Well, like its array the Gaia mission's goals are vast.

Primarily it is a survey operation, its main objective being to create the largest and most precise 3D map of our Galaxy. It will achieve this by analysing one billion of the Milky Way's stars, which is about one per cent of its population. Gaia's instruments will repeatedly scan the sky, observing each of these billion stars an average of 70 times over the five years of the mission's life. As well as the positions and motions of the stars, Gaia will measure the key physical properties of the celestial bodies in its field of view, building a picture of the brightness, temperature and chemical composition for each.

More than a star mapper

By analysing this data astronomers hope to understand the history and evolution of our Galaxy, looking at star formation, star death and the reuse of heavier elements in these processes. Such a detailed survey is also likely to increase the number of exoplanets we know of: it is expected that Gaia will detect between 10,000 to 50,000 new Jupiter-like planets by measuring the small wobble that these planets create on their local stars.

Due to Gaia's supersensitivity it will also be able to detect a multitude of faint objects closer to home – minor planets, comets and asteroids – useful for cataloguing near-Earth objects, which are often hard to see and have the potential to be devastating if left undetected.

The data flowing out of the project will not only be immense, but also available to the public. A number of school projects will allow children access to real scientific data to process. And for scientists, the huge amounts of Gaia data coming in over the next few years could prove to transform our understanding of our place in the Universe.

But to my mind, we are just following in the paths of our ancestors. The first recorded star charts and almanacs date back thousands of years. We are merely continuing a long-standing tradition – albeit with accuracies and instruments that would not only have astounded our ancestors, but that even by today's standards are really quite mind boggling.

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

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JON CULSHAW'S EXOPLANET EXCURSIONS

Jon tracks down another alien eclipse – this time involving a mighty gas giant

As 20 March approaches I find myself thinking more and more about pristine, clear skies for nature's most spectacular sight, the total solar eclipse that will be visible from the Faroe Islands.

I vividly remember the eclipse of 11 August 1999, seen from a ferry on the English Channel. There were sufficient cloud gaps to fuel optimism about a spectacular view. BBC weather presenters gave commentary over the Tannoy about where the ship was steering to find gaps in the clouds, while Uri Geller moved among the passengers talking about 'The Energies'.

I'll never forget the strange, steel-grey twilight that enveloped us shortly before totality: a unique, monochrome dusk with a weird silvery glow, which only impending totality could create. As Patrick Moore might say, "It was frankly... eerie."

So, keeping our visions profound on these excursions, I'm going to see a red giant star eclipsed by a great gas giant. My destination is HD 208527, a red giant that lies some 1,044 lightyears from Earth in the constellation of Pegasus. The gas giant orbiting it bears the name HD 208527b, but I'm going to name it 'Jupideci' – after all, it does have a mass of around 10 times that of Jupiter.

Jupideci sits 2.1AU away from its parent star – quite possibly nestled within its habitable zone – and takes about 876 days to complete an orbit. Any Moons orbiting this world may well possess liquid water and the possibility of life. The redness of the star itself is reminiscent of observing our Sun in hydrogen-alpha.

As the dark disc of Jupideci advances to obscure its parent red giant, my anticipation of witnessing an alien eclipse is beyond palpable. In the moments leading to exo-totality, the thinnest crescent with a smouldering ochre glow pulsates against the solid blackness of space. The red giant eclipse hangs in this alien skyscape like a sickle freshly removed from a blacksmith's forge. Sensing the scale of the objects involved, totality arrives with the surety of a massive ocean vessel steadfastly occupying its place in dock.

The sight is utterly magnificent. Unlike solar eclipses visible from Earth, which have a solid black inner outline, the black disc here has a softer, blurry edge. The outer layers of the gas giant allow a little of the red giant's light to shimmer through. It's a charming nuance of this eclipse.

The blackness of the Jupideci disc is surrounded by a halo glowing the deepest orange shade of volcanic magma. It's similar to our Sun's corona but with a softer, less filamented structure. It brings a sense of being bathed in the cosy glow of a Victorian fireplace on a cosmic scale. If the Cruise Globe's robotic arms were able to stretch out far enough, I'd be tempted to stick a slice of bread on the end for some space toast.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION BY MARK GARLICK, PHOTO: EMMA SAMMS

Interactive

EMAILS • LETTERS • TWEETS • FACEBOOK

Email us at inbox@skyatnightmagazine.com

This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's. Heather Couper and Nigel Henbest's *Stargazing 2015* is a month-by-month guide to the year and you'll be able to find all the best sights with Patrick Moore's *The Night Sky*. *Stargazing with Binoculars* by Robin Scagell and David Frydman contains equipment and observing guides, and you'll be viewing planets, galaxies and more with Storm Dunlop's *Practical Astronomy*.

PHILIP'S

MESSAGE OF THE MONTH

How I proved the Moon landing wasn't faked

An elderly acquaintance asked me about the famous Apollo 11 lunar footprint photo. I don't think she had totally erased from her mind the idea that the whole lot was faked. I had a quick think, and in the course of the discussion on the regolith I was repeatedly interrupted by comments that 'there's no water on the Moon' (the implication being that the surface cannot be – or behave like – clay or mud) and that 'sand won't stay put' – so I couldn't possibly come up with an explanation.

Well, I wasn't going to be beaten by this. I did some research and ascertained that the thin layer of fine dusty regolith that overlays the coarse stuff has a mean particle size of 72μm and a bulk density of about 1.5. I decided to do an experiment. With lunar gravity at about one-sixth that of Earth's, I needed a material with one-sixth the density of regolith, comparable particle size, and a surface that would generate pretty ordinary Van der Waals forces (the small electrical forces that make all matter stick together very slightly).

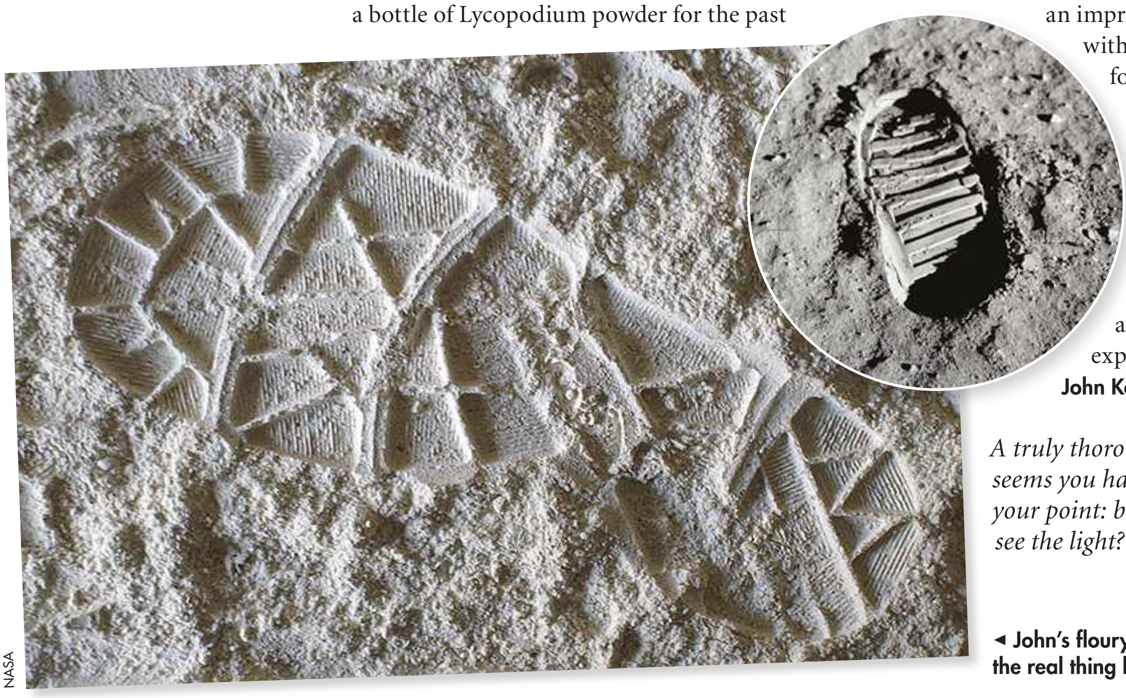
Bread flour has a mean particle size of about 50μm and a bulk density of 0.48: a ratio of regolith/flour of about three, so I really wanted a material with about half the density of flour. I have kept a bottle of Lycopodium powder for the past half century in case it came in useful sometime. I looked on the internet again and found that Lycopodium spores are about 40μm – ideal. But nowhere could I find the bulk density, except in a blog that read "an ounce will fill more than a half cup volume measure". Apparently this American cooks' measure is 8.3 fluid ounces, near enough the volume of 8.3oz of water. So Lycopodium will have a bulk density of approximately one divided by 4.15, which equals 0.241. So, the ratio of densities regolith/Lycopodium is 1.5 divided by 0.241, which equals 6.2, near enough identical to the ratio of Earth/lunar gravity. But unfortunately, in my hour of need, I was unable to locate the bottle!

So, it was back to bread flour. Spacesuits are heavy: I looked up the weight of the kit and it was 91kg. Kitted up, an astronaut weighed about twice an average man, but in reduced lunar gravity this would have been about one-third of that weight – the final piece of data for my experiment.

I suffer from hot feet, and wear sandals year-round. It would be a disaster if a pair were to collapse in winter, so I keep an unworn pair in stock. I filled a small tea tray with flour and made an impression with a pristine sandal, with a pressure of about 15kg (one foot: they jump, not walk, on the Moon). In five minutes I had a perfect fake lunar footprint, but it took 10 minutes to clear up the mess, and get the flour back into the bag for its intended use. I gave the photo to my acquaintance, along with an explanation of what I had done.

John Kemp, Whitstable

A truly thorough experiment John. It seems you have well and truly proved your point: but did your acquaintance see the light? ***– Ed***



NASA

◂ **John's floury lunar footprint mock up; inset, the real thing left by the Apollo 11 astronauts**

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: What is your favorite nebula name and why?

Phil Marriot: Horsehead Nebula every time! It's so dramatic and clear. Most people that are not into astronomy do not believe that it can be real.

@horburyastro: got to be the Footprint Nebula. Surely a sign someone out there has been walking around.

Jo Fenwick: Pillars of Creation. Looks amazing every time I see it.

@padraigofrankly: Gomez's Hamburger! I can't think of any other edible nebulae...

@neilmr38: Horsehead Nebula, it's lovely to image.

Mark Tissington: I like the Blue Snowball Nebula, NGC 7662, because it sounds like a cocktail. Ideal for star parties...

More than just a shed

I wanted to build an observatory in my garden, but after looking at the pre-made ones and kits, I discovered that were very expensive! They were all out of my price range so, after an online search, I had the idea that I could build one myself for a lot less. It took a friend and myself a day to build and now I have my own observatory for under £500!

Paul Sharp via email

Well done Paul! With a little ingenuity luxuries like this don't have to cost the Earth. ***– Ed***

▲ **Paul converted an everyday garden shed to make his budget observatory with sliding roof – good work!**

Earth in the frame

When looking at the excellent deep-sky images often featured in *Hotshots*, I sometimes try to imagine how the same scenes would appear if seen from a location set a few hundred lightyears from Earth. The overall view would be the same, I think, a few hundred lightyears not being enough to drastically alter the appearance of objects that are typically thousands if not millions of lightyears away in the first place. The only obvious difference would be an extra sprinkling of previously absent foreground stars, one of which would be our Sun! Imagine us, adding our tiny fragment of sparkling magic to somebody else's view of the hauntingly beautiful Horsehead Nebula.

Rod Ingle, Essex

What a wonderful thought Rod. We too are inspired every month by the incredible images sent in by our readers! ***– Ed***

Archie searches for 'tars' in the November issue

Just like his father

I thought you might like to see our son Archie enjoying your magazine. At 18 months old, he loves sharing Daddy's magazine every month, particularly looking for the Moon and 'tars'. We also have to go out every night before his bedtime, as he stands at the back door shouting "Moon!" A young astronomer in the making maybe?

Claire Hearth, via email

Who needs fables when you've you got astrophysics? An astronomer in the making indeed Claire. ***– Ed***

Our Sun's tiny paunch

I was very intrigued in June 2014's *A Passion for Space* (page 23), about why our Sun has no bulge. Years ago I worked on gyros and discovered that the Sun, Jupiter and the Earth are no more than gyros themselves, all turning freely in space at different speeds. Using the data provided in the article, I calculate that the Sun's bulge is 0.012 per cent, which is very small and would be hard to see or measure on the volatile surface of the Sun.

Brian Drew, Doncaster

An interesting finding Brian. It is a wonder that our turbulent star can be so accurately measured. ***– Ed***

Honestly, the dog ate it

Is it possible to have a replacement disc from the December 2014 issue? Unfortunately our five-month-old wolfhound puppy stole it from the table after I took it off the magazine and before I realised, had started to chew. I did try to run the disc once I had retrieved it, but unsurprisingly it came back with an error. I haven't missed a copy over the last seven years and it is lovely to look back on previous issues.

Keith Richards, via email

What an inquisitive puppy Keith. A replacement CD is in the post to you; make sure you get to the letterbox first! ***– Ed***

Nonchalant as ever, puppies can get away with anything

OOPS!

- The incorrect Jupiter moons diagram was printed in January's *Sky Guide* (page 53). You can find the correct graphic for January 2015 on our website at: **www.skyatnightmagazine.com/jupiter's-moons-january-2015**

- The picture labelled as the Beehive Cluster on page 92 of January's issue is captioned incorrectly. It is actually open cluster M35 in Gemini.

- In January's *First Light* on page 98, the camera reviewed is misspelt in the headline. It should be: iNova NBB-Cx.

Hotshots

This month's pick of your very best astrophotos

▲ IC 405

CHRIS HEAPY, MACCLESFIELD, 25 OCTOBER 2014

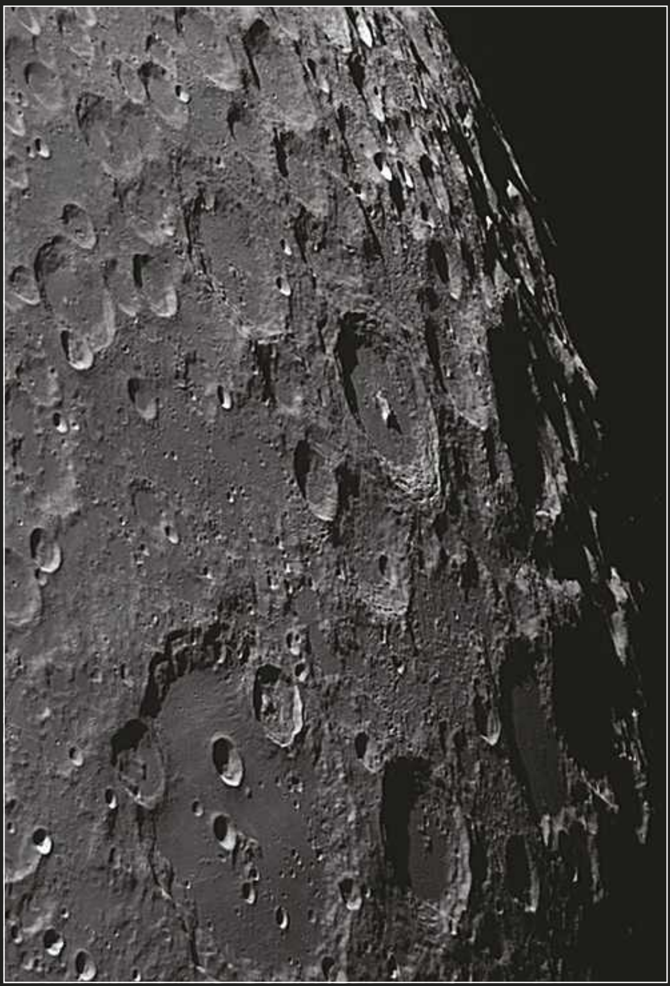
Chris says: "IC 405 contains the Flaming Star Nebula, and indeed I have an RGB image that shows this classic blue reflection nebula, but what fascinates me is the texture of the underlying gas and dust cloud when viewed in the hydrogen-alpha light of this monochrome image. I find the complex knots and ripples make it a particularly beautiful object."

Equipment: Atik 490EX CCD camera, Tele Vue NP127 refractor, Losmandy G11 mount.

***BBC Sky at Night Magazine* says:** "Every so often a monochrome image manages to capture detail and texture absent from its colour counterparts. This stunning shot achieves just that. We were struck by the detail in the nebula's intricate tendrils and the wispy filaments that dominate the left side of the image."

About Chris: "I've had a lifelong passion for astronomy, but it is only since retiring that

I've found the time to pursue astro imaging as a discrete interest. In my younger days I concentrated on visual observing, mainly using a 12-inch Newtonian and a 10-inch Meade LX200. When the first digital cameras came out I immediately recognised the possibilities for attaching one to a scope and paid over £500 for a Sony DSC1 so I could image the Moon!"



◀ The southern highlands of the Moon

JOHN CHUMACK, OHIO, US, 2 NOVEMBER 2014

John says: "This is one of my sharpest southern highlands shots to date – craterlets galore! Lunar highlands are very different from maria in many ways. Radioactive dating of lunar samples from both types of surface reveals that rocks from the highlands are mostly around four billion years old, with the oldest dating back 4.4 billion years. Maria rocks are younger, dating from 3.1-3.8 billion years ago, about the same time as the oldest terrestrial rocks."

Equipment: QHY5IIL CCD camera, 10-inch Schmidt-Cassegrain.

▲ Jupiter and its moons

JOHN SHORT, TYNE AND WEAR, 22 NOVEMBER 2014

John says: "This image shows Jupiter and three of its moons and was taken with a DSLR camera."

Equipment: Canon EOS 6D DSLR camera, Celestron 8SE telescope.

▼ The Pelican Nebula

CHRIS GRIMMER, NORWICH, 1 OCTOBER 2014

Chris says: "The Pelican Nebula is part of a large emission nebula in the constellation of Cygnus. It is part of the North America/ Cygnus Wall area, but is defined by a large dust cloud, which from our viewpoint on Earth appears to separate it from this region."

Equipment: Starlight Xpress SXVR H694 monochrome CCD camera, William Optics GT81 Triplet refractor, iOptron CEM60 mount.

▲ The Triagulum Galaxy, M33

CHRIS BAKER
NERPIO, SPAIN, OCTOBER 2014

Chris says: "To accentuate the nebulosity in this image I captured two hours of hydrogen-alpha data. The amazing nebulosity shows up brightly across the frame, including the incredible NGC 604 in the upper part of the galaxy, which is apparently seven times the size of the Orion Nebula!"

Equipment: QSI 683WSG CCD camera, Takahashi 150 telescope, Paramount Bisque mount.

▲ The Andromeda Galaxy, M31

IAN RUSSELL, OXFORDSHIRE, 21 OCTOBER 2014

Ian says: "I have tried to image the Andromeda Galaxy before, but couldn't quite fit the entire object in the field of view. Adding a focal reducer to my Takahashi FSQ85 framed this beautiful galaxy nicely."

Equipment: Atik 490EX CCD camera, Takahashi FSQ85 telescope, iOptron CEM60-EC mount.

▲ Orion's Belt

JAMES COARD
LISBURN, 23 NOVEMBER 2014

James says: "I had planned to get up very early to image Orion but overslept, only managing to photograph the constellation as it started to set behind some trees. I was still pleased with the result, especially as there is a hint of nebulosity around the belt star Alnitak."

Equipment: Canon EOS 5D MkIII DSLR camera, 70-200mm lens, iOptron SkyTracker mount.

Star trails ▶

JORDI FRAXANET
SOLSONA, SPAIN, 1 MARCH 2014

Jordi says: "I wanted to photograph the pole star with something terrestrial in the foreground; an old chimney was the perfect choice. This is a single frame of 20 minutes. I like the contrast between the building close by and the distant stars."

Equipment: Canon EOS 400D DSLR camera, Zeiss 50mm lens.

ENTER TO WIN A PRIZE!

The Widescreen Centre since 1971 London's Astronomy Showroom

We've teamed up with the Widescreen Centre to offer the winner of next month's best Hotshots image a fantastic prize. The winner will receive an Orion StarShoot Solar System Colour Imager IV camera, designed for capturing sharp shots of the Moon and planets.

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Email your pictures to us at hotshots@skyatnightmagazine.com or enter online.

NEW FOR 2015
EXTRA PRIZES

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

The new-look competition is now ready for you to submit your entries

The world's premier astro imaging competition is back for its seventh year – and it's been completely revamped to better represent the rising number of entries. As well as gaining a title sponsor in the form of Insight Investment – a leading European investment manager – there are now eight categories and a total of 32 prizes to be won, so there has never been a better time to flaunt your imaging talents for all to see.

With more categories, the organisers have been able to separate images that would have previously been grouped together. They are: Aurorae; Skyscapes; People and Space; Our Sun; Our Moon; Planets, Comets and Asteroids; Stars and Nebulae; and Galaxies.

In addition, there are also two special prizes: Robotic Scope and The Sir Patrick Moore Prize for Best Newcomer. There is also a separate competition open to all entrants aged 15 and under – the Insight Astronomy Photographer of Year Young Competition, for which there are five awards.

"The new spread of categories shows just how vast and inspirational a subject the night sky is," says Melanie Vandenbrouck, curator of art for Royal Museums Greenwich and one of the judges behind the restructure. "I think having more categories means that people who might have hesitated entering the competition before will feel more confident doing so."

Go for the unfamiliar

Whether you enjoy imaging the sky as a backdrop to Earthly scenes, or showcasing your skills by capturing the most distant objects we can see from the surface of our planet, an artistic eye or a novel approach might earn you the grand prize.

"What always surprises me is the new ways that people find to photograph familiar objects," says Marek Kukula, Public Astronomer at the Royal Observatory in Greenwich. "Every year someone manages to come up with something that we've never seen before."

Last year saw the first entry taken from a weather balloon on the edge of space. Other submissions to the 2014 competition included the swirling clouds of gas beneath the Horsehead Nebula – usually invisible in images – and unusual monochrome shots of familiar sights such as star trails. But out of more than 2,500 entries from 51 countries, it was James Woodend from the UK who claimed the prestigious title of Astronomy Photographer of the Year 2014 with a stunning auroral image taken in Iceland.

All of the winning images will be displayed at the Royal Observatory Greenwich

DATES TO REMEMBER
COMPETITION OPENS FOR ENTRIES: 15 JANUARY
COMPETITION CLOSES: 16 APRIL
EXHIBITION OPENS: 18 SEPTEMBER

"Don't be self-conscious, or scared by the technical aspects," says Vandenbrouck. "Just keep looking up, keep being inspired, and send us the shots that inspire you about the splendours of the Universe."

Whether you are a novice new to astronomy or an expert with many years experience, the Insight Astronomy Photographer of the Year 2015 contest offers more opportunities to have your work displayed at the Royal Observatory Greenwich than ever before.

HOW TO ENTER

To enter your astro images into the competition you will need to upload them to your Flickr account. For full details of how to do this and then submit your images, visit the competition website: www.rmg.co.uk/astrophoto

ALL NEW CATEGORIES

This year there are eight categories. In all but one, a winner, runner up and highly commended entry will receive £500, £250 and £125 respectively. Skyscapes has its own prize structure in 2015 – more about this in the entry below. The winner of the £2,500 grand prize and the accolade of Insight Astronomy Photographer of the Year 2015 will be chosen from all eight category winners plus the winner of the Young Competition.

AURORAE

Any image featuring the aurora belongs in this section. Auroral displays are always popular, as they are often seen above beautiful landscapes. Last year James Woodend won the overall competition with this image of the aurora reflected in a glacial lagoon.

NATIONAL MARITIME MUSEUM, JAMES WOODEND, MATT JAMES, EUGEN KAMENEW

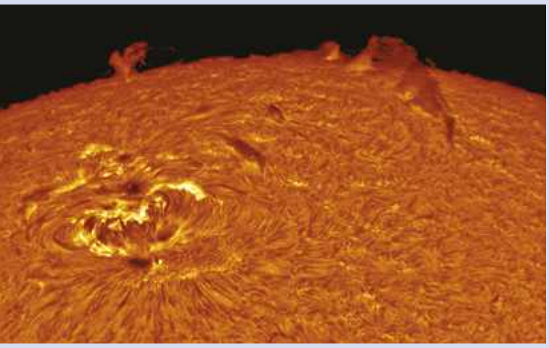
SKYSCAPES

SPONSORED BY INSIGHT INVESTMENT

Whether it is filled by the Milky Way, the Moon or meteors, the night sky can provide a stunning backdrop. Images that feature Earth-based scenery set against a celestial backdrop belong in this category, so long as they don't include people or the aurora. The winner, runner up and highly commended entry will receive £1,000, £500 and £250 respectively. Matt James was named a 2014 runner up for his monochrome image of star trails over wind turbines, below.

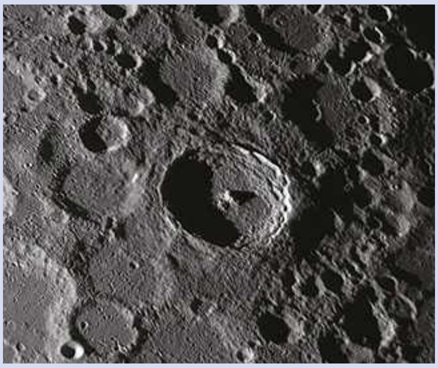
PEOPLE AND SPACE

Since its introduction in 2010, People and Space has been one of the most popular categories as it highlights our place within the cosmos. It remains a category for any image featuring a human figure as well as an astronomical sight. Last year Eugen Kamenew won the prize with his image of a native Kenyan silhouetted against the solar eclipse.



OUR MOON

The Moon is one of the most prominent objects in the night sky, and there are countless ways to capture its beauty – you could image its entire surface or focus in one a small area, as 2014 runner up George Tarsoudis did in this shot of crater Tycho.



OUR SUN

The total solar eclipse in March will give the chance to create a unique record of the Sun, while both white light and hydrogen-alpha images can show some of the beauty found every day on our nearest star. Alexandra Hart won this category last year with her image of the ripples on the Sun.

PLANETS, COMETS AND ASTEROIDS

If your image features objects from our Solar System other than the Moon, Sun and Earth then it belongs in this category. Last year Olivia Williamson was highly commended for her image of Mars, which perfectly shows the planet's varied albedo features.

STARS AND NEBULAE

The category for any deep-space object within our Galaxy, covering everything from stars to the nebulae that birthed them. 2014 winner Bill Snyder had to take 12.8 hours worth of exposures to capture the detail at the base of the Horsehead Nebula that is often left unseen.

GALAXIES

While possibly one of the most difficult groups of targets to image, galaxies are among the most beautiful objects in the night sky. In 2013 Ivan Eder was highly commended for his entry of M81-82 and the Integrated Flux Nebula.

SPECIAL PRIZES

There are two special prizes, with each winner awarded £350

THE SIR PATRICK MOORE PRIZE FOR BEST NEWCOMER

This special prize is open to entrants who have taken up astrophotography since January 2014 and have not entered the competition before. Any subject can be depicted. Chris Murphy took the prize in 2014 with this stunning shot of the Milky Way over the coast of New Zealand.

ROBOTIC SCOPE

Many professional robotic telescopes are now available for public use. This award allows you to showcase images taken with these great tools. Mark Hanson took this winning shot of warped spiral galaxy NGC 3718 for the 2014 contest remotely using the Doc Greiner Research Observatory in New Mexico.

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR YOUNG COMPETITION

This category is open to all entrants aged 15 and under. Entries can depict any astronomical subject; Shishir and Shashank Dholakia won last year with this image of the Horsehead Nebula. Entires need to be uploaded via a dedicated entry form available at **www.rmg.co.uk/astrophoto**. The winner will receive £500, the runner up £250. Three highly commended prizes of £125 will also be awarded.

ALEXANDRA HART, GEORGE TARSOUDIS, OLIVIA WILLIAMSON, BILL SNYDER, IVAN EDER, CHRIS MURPHY, MARK HANSON, SHISHIR AND SHASHANK DHOLAKIA

MAXIMISE YOUR DEEP-SKY OBSERVING

There are a handful of techniques that cost nothing but, once mastered, can vastly improve your ability to observe faint night-sky targets. **Martin Lewis** reveals them

Much of the appeal of astronomy comes from the visual appreciation of celestial objects, whether they are seen directly through the eyepiece or indirectly in images taken by space telescopes. But when it comes to direct observing, there are a number of things you can do to get better views. Understanding how the eye and brain work best together is one; developing special observing techniques another. Over the next few pages, we're going to look at some of these tried and tested methods, which can help you to spot faint objects and examine low-contrast detail.

ABOUT THE WRITER

Martin Lewis is a keen astronomer. As a regular *First Light* reviewer, he has in-depth knowledge of observing with all sorts of equipment.

USING **HIGH MAGNIFICATION**

Knowing when to boost the magnification of your setup will help to reveal hidden detail

Complex bodies like the Whirlpool Galaxy require a range of magnifications to explore fully

ONE MIGHT IMAGINE that using lower eyepiece magnifications would make detail in deep-sky objects easier to see by increasing the object's overall surface brightness. However, this is generally not the case: higher magnifications usually allow you to see more detail.

As you increase your magnification two changes occur that affect the visibility of low-brightness and low-contrast detail in deep-sky objects. The most obvious change is that the detail gets larger, clearly making it more visible. The second change is that both the background brightness and the object brightness fall. Even though the relative contrast stays the same, this decrease in brightness makes things harder to see. Up to an optimum magnification, the benefit of increased size more than outweighs the fall in brightness – you'll find that increasing magnification actually allows you to see more detail. Beyond the optimum, the benefits of further boosting the size tails off and things then become harder to see overall because the falling brightness wins out.

The brain and eye work best when the detail you want to see appears 1-2° across. So experiment at the eyepiece, increasing the magnification until image details are about this apparent size. In a large complex object like the Orion Nebula or the Whirlpool Galaxy, where there are a range of different detail sizes, brightnesses and contrasts, you will probably find that you need to use a range of different magnifications to pull out all the different detail present – lower magnifications for the really large features and higher magnification for the finer detail.

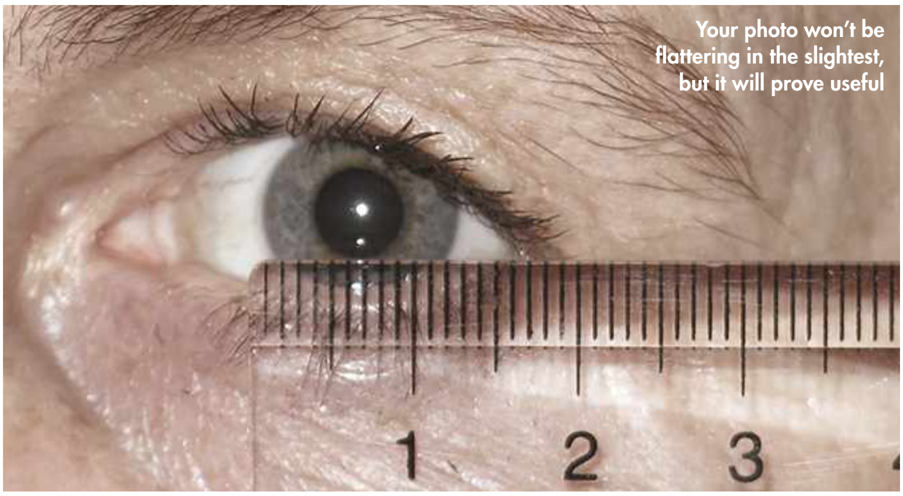
Targets with high surface brightness and fine detail, such as the Eskimo Nebula or the Cat's Eye Nebula, can benefit from really bumping up the magnification to see all the detail present, but do pick a night where the atmosphere is steady. High powers can also be used to advantage to enable you to see the faintest stars in globular clusters or to detect small faint galaxies. Such objects at the threshold of vision are regarded as point sources by the eye and brain. This means that increasing the magnification leaves them unaffected but darkens the sky, so increase the effective contrast and allow them to pop into view.

MEASURING YOUR **PUPIL SIZE**

This small piece of research will help you to optimise magnification at the eyepiece

THE SIZE OF your fully dilated pupil influences both your telescope's minimum useful magnification and a deep-sky object's maximum surface brightness (see 'Using Low Magnification', page 39).

To measure your pupil's maximum diameter hold a millimetre-scale ruler close to your eye in a dark room and take a close-up flash photo (with pre-flash option turned off). It won't be that enjoyable an experience, but it will allow you to determine your pupil size by reading off the diameter using the millimetre scale in the photo. Divide your telescope's aperture (in millimetres) by your pupil size to find the minimum useful magnification. ▸



Your photo won't be flattering in the slightest, but it will prove useful

ISTOCK X 3, MARTIN LEWIS X 2

For some, staring into the Milky Way's vastness is a reminder of how small Earth actually is

THE REWARDS OF **VISUAL OBSERVATION**

Amateur astronomy is far from being solely a tick box exercise

MANY NON-ASTRONOMERS think that the rewards of visual astronomy come just from staring at things that are inherently beautiful to look at such as Saturn, the Moon or the Orion Nebula. Although aesthetic appreciation is certainly part of it, there are actually only a handful of objects that fit this bill.

For most astronomers, there are other rewards that keep them looking on those long, cold, nights; rewards that transform those glimpses of 'faint fuzzy blobs' and indistinct patches into wonderful distant, interacting galaxies.

Such rewards will be different for each observer, but many amateurs have developed a frame of mind in which some of the following may be appreciated.

First, a sense of awe: a contemplation of the vastness of space or the aeons that have passed, both in order to create the object as it currently appears, and during which its photons have travelled through space to reach your retinas.

Also, a sense of peace: a calming, therapeutic effect of being under the silent and open heavens, which puts the challenges of daily life into perspective.

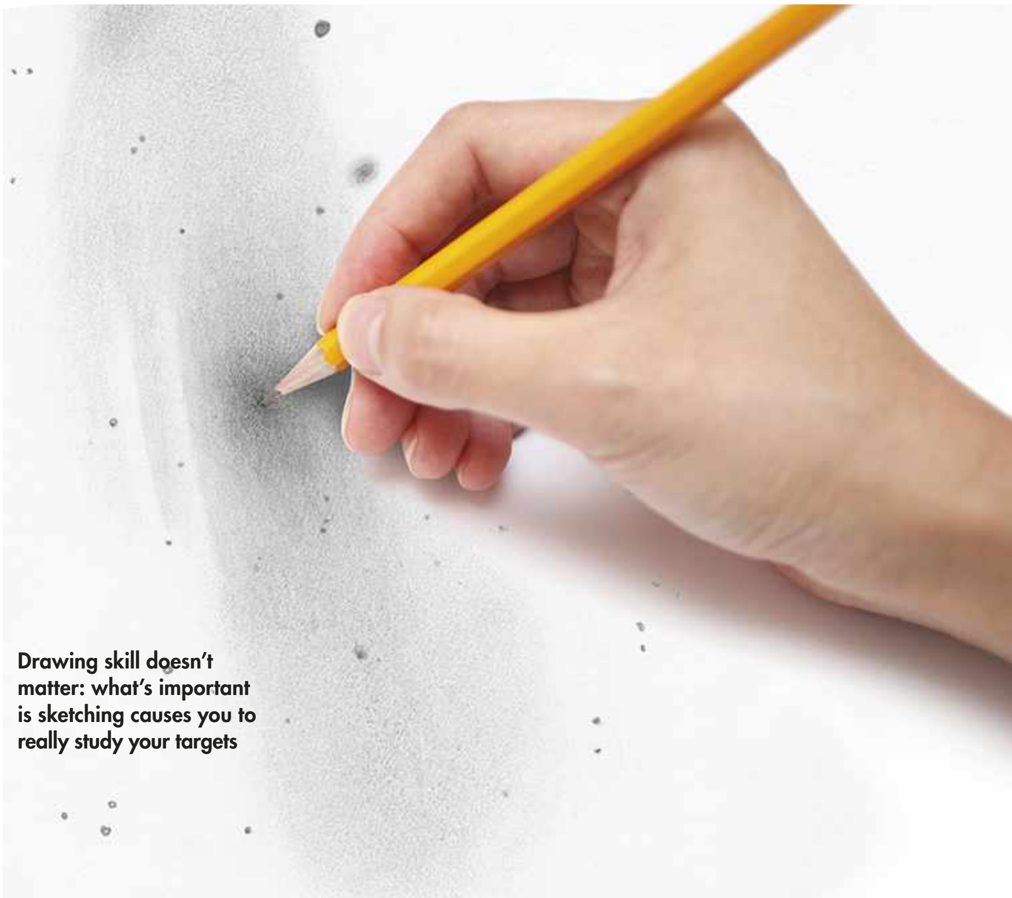
There's also the feeling of rising to a challenge. Detecting faint objects or seeing difficult detail within objects, such as all five members of Stephan's Quintet or the central star of the Ring Nebula, is immensely satisfying and shows that progress is being made as you continue to explore.

SKETCHING **THE DEEP**

Picking up the pencils can hone your observing skills

IF YOU WANT to spend time really looking at deep-sky objects rather than racing on from one to the next, then try doing some sketches of what you see in the eyepiece. It's a great discipline that forces you to make decisions about whether you really can see particular details: you can't do this without properly looking.

You don't need to be an artist to try this – after all you can keep your drawings private – but sketching will give you an opportunity to hone some of the observing techniques listed here and really help you to remember what you saw in the eyepiece, not to mention giving you something to appreciate on cloudy nights.

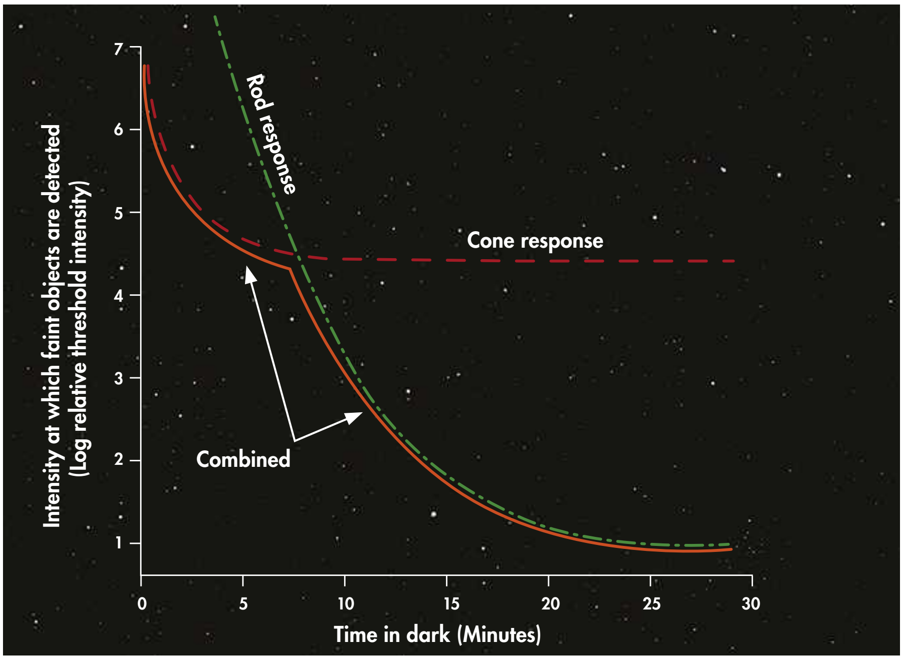


Drawing skill doesn't matter: what's important is sketching causes you to really study your targets

ESO/A. FITZSIMMONS/SCIENCE PHOTO LIBRARY, ISTOCK X 2, MARTIN LEWIS, GRAPH BY PAUL WOTTON/REF: MARTIN LEWIS

DARK **ADAPTATION**

Allowing adequate time for your vision to adjust to darkness can deliver huge gains



DARK ADAPTATION ALLOWS our eyes to see more clearly in conditions of low light. This key technique relies on two changes in the eye, one fast and one slow.

The rapid change is where the eye's pupil dilates to its maximum diameter, allowing more light to reach the retina where it triggers nerve impulses. For the naked eye, dilation increases the eye's light gathering capability by about 16 times. When using a telescope, the pupil's maximum dilated size determines its lowest useful magnification as well as an object's maximum surface brightness. So for high and medium magnifications, where the eyepiece exit pupil is much smaller than the dilated pupil, dilation gives little benefit.

The second slower but potentially much larger improvement in eye sensitivity happens thanks to chemical changes that occur in the retina in the absence of light. Such changes can increase its sensitivity by an amazing one million times.

The retina contains two kinds of light-sensitive cells, rods and cones. Cones can detect colour and brightness and are generally used for daytime vision. Rods can potentially be much more sensitive but don't detect colour, and because their density is lower their resolution is limited. When you go from a bright environment to a dark one the retina's sensitivity begins to improve immediately. To start with, the colour-sensitive cones adapt most quickly and are the more sensitive, but after about 10 minutes their improvement tails off and the rods take over, reaching maximum sensitivity after about 30 minutes.

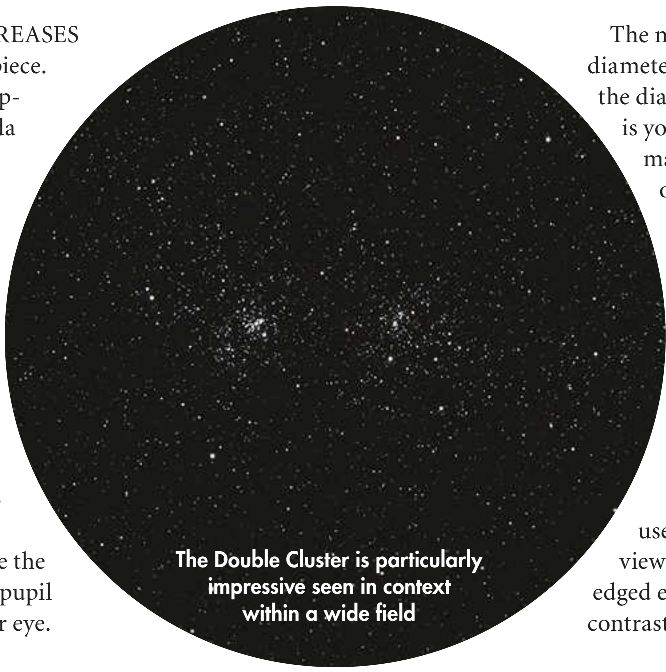
There's a reason astronomers use dim red lights to work at night. To read maps and equipment settings in the dark, you need to use the better resolution of the colour sensitive cones rather than the lower resolution rods. At the red end of the spectrum the rod and cone sensitivities almost match, allowing for high-resolution colour vision from the cone cells with minimal excitation of the rods, so preserving dark adaption.

USING **LOW MAGNIFICATION**

Increasing the amount of sky visible in the eyepiece can have some surprising benefits

LOWER MAGNIFICATION INCREASES the area of sky visible in your eyepiece. This allows some of the larger deep-sky objects, such as the Andromeda Galaxy or the Double Cluster in Perseus, to look better by giving them a surrounding frame of darker background sky.

Dropping the eyepiece power also has the effect of increasing an object's surface brightness by concentrating its light over a smaller angular area. As the power is progressively dropped the diameter of the bundle of light leaving the eyepiece – the so-called 'exit pupil' – also increases. Eventually a limit is reached where the exit pupil is larger than your own pupil and not all the light can enter your eye.



The Double Cluster is particularly impressive seen in context within a wide field

The magnification that matches the diameter of the eyepiece exit pupil with the diameter of your fully dilated pupil is your telescope's lowest useful magnification – to find out the size of your exit pupil, see 'Measuring Your Pupil Size' on page 37. At this magnification the surface brightness of a deep-sky object reaches a maximum. Some objects, such as the Orion Nebula, may be bright enough to excite some of the cone cells in your eye, which may allow you to see some faint colour.

Lower powers, combined with the use of movement, can also help with viewing the extremeties of very soft-edged extended objects by increasing the contrast gradient at those edges. ▸

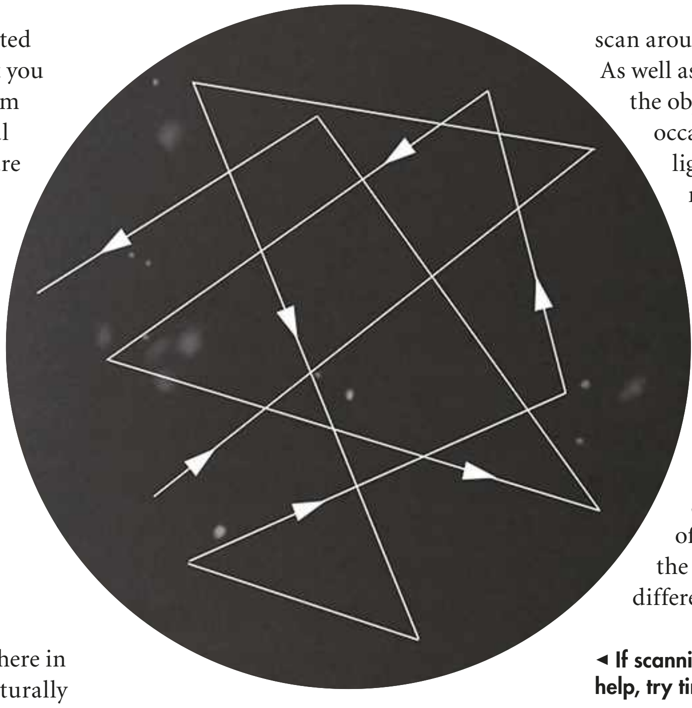
USING **MOVEMENT**

Scan around the field of view to stop your brain from mistaking dim targets as 'noise'

WHEN YOUR FULLY dark-adapted eyes are working in very low light you will probably notice lots of random flashes, sparkles and other general background noise. If you then stare fixedly through the eyepiece, even using averted vision, any low-contrast object will fade from view. This is because the eye and brain will just treat the object as part of this background noise. Scan your eye around the field, however, and you stand a much better chance spotting your target. When the retina is exposed to a dim, low-contrast pattern that is moving, the brain recognises it as something real rather than background noise.

To detect a faint galaxy somewhere in the eyepiece, allow your eye to naturally scan around the field of view at random. As well as creating some movement of the object on the retina, the image will occasionally land on the retina's more light-sensitive peripheral parts, making the galaxy briefly visible.

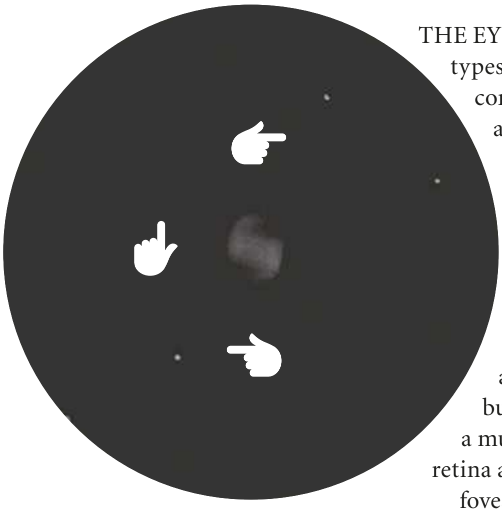
Even with the eye scanning around the field, the brain tends to ignore spread-out areas with a low-contrast gradient. If these areas are moved relative to the darker edges of the eyepiece field, however, they then become much easier to see. Try using small back and forth movements of the telescope or repeatedly tap the side of the eyepiece and see the difference it makes.



◄ **If scanning the eye around the field doesn't help, try tiny movements of the telescope**

AVERTED **VISION**

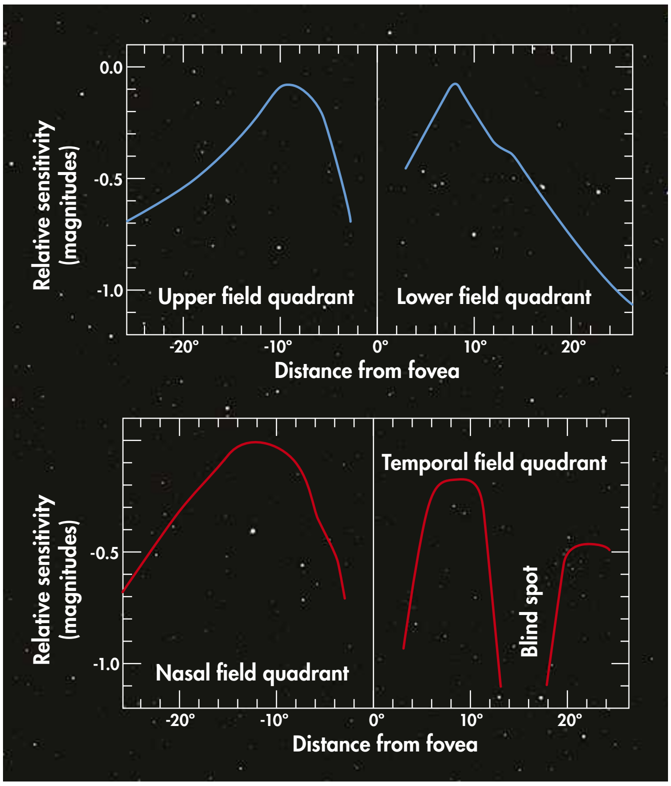
Looking away from your target can give you a better view than a direct stare



▲ **Averted vision involves looking 10° to the side of your target – just make sure you avoid the blind spot**

THE EYE'S RETINA has two types of light receptor cells: cones and rods. Cones allow us to see colour and detail, and have a very high density at the centre of your retina, in the fovea, which creates the centre of your vision. The colour-blind rods are more numerous but are spread out over a much larger area of the retina and away from the fovea. In a fully dark-adapted eye the rods are far better than cones at detecting faint light, and it is these cells you generally use at night.

The charts on the right show that the sensitivity of the dark-adapted eye peaks at about 8-15° from the fovea, where the rod density is the highest. This suggests a useful technique of pointing your vision about 10° to one side of an object of interest but keeping your attention and interest directed on it. This technique, called averted vision, may seem a bit unnatural to start with, but you will soon get the hang of it. And it is worth doing so – it can dramatically improve your ability to see faint objects and dim details. For best results keep your eye moving, placing the object above or below the centre of your vision or on the nose side of your fovea. Do, however, avoid the opposite side to this, where the blind spot is located.



▲ **The sensitivity of a dark-adapted eye peaks at 8-15° from the fovea**

TOP TARGETS **TO TEST YOUR SKILLS**

Master the tips and techniques here and you'll have no difficulty exploring these objects

M106

RA 12h 20m, dec. +47° 14′

M106 is an 8th-magnitude spiral galaxy in the constellation of Canes Venatici and is highest in evening skies in spring. It's possible to see M106's delicate spiral structure within the general elliptical halo in good skies and larger instruments by increasing the magnification until this structure has an apparent size of about 1°. This is the size at which the eye and brain work together best to see dim, low-contrast detail.

THE SWAN NEBULA, M17

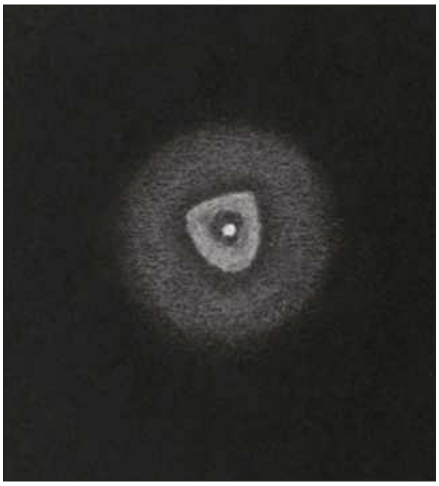
RA 18h 22m, dec. –16° 10m

The Swan Nebula lies at the northern edge of Sagittarius and is best in August evenings, when it is low in the southern sky. Use an ultra-high contrast filter and low powers to frame the object nicely with some background sky, but use higher magnifications to pull out details like the finer points of the Swan's neck on the western side. Practice your averted vision to see the fainter separate nebulous region off the eastern side.

COPELAND'S SEPTET

RA 11h 39m, dec. +21° 56′

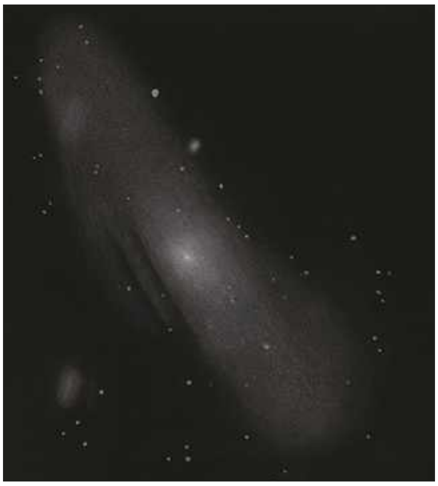
Copeland's Septet is a compact group of small galaxies in Leo, best seen in spring. The galaxies range from mag. +13.7 to +15.2. The brighter members are not too difficult to spot in 8-inch or larger scopes under dark skies but to see all seven members is harder. Good dark adaption and averted vision are essential; also switch to using higher powers to darken the background, improve the contrast and allow the fainter members to be detected.



THE ESKIMO NEBULA NGC 2392

RA 7h 30m, dec. +20° 53′

The 9th-magnitude Eskimo Nebula in Gemini is seen at its best in winter months. Its high surface brightness allows you to use high powers to best bring out details of the centre, especially the Eskimo's face, although you will need steady skies. In very good seeing conditions try bumping the power right up by using a Barlow lens with your eyepiece. If the view deteriorates, back off a bit.



THE ANDROMEDA GALAXY, M31

RA 0h 43m, dec. +41° 21′

The huge Andromeda Galaxy, which is nearly overhead in late summer and autumn, is a great object to practise the use of lower magnifications combined with sweeping the eyepiece to create the movement within the field that will allow you to pick up the edges of the very low gradient eastern (lower) edge. Use higher magnifications to pull out details of the dust lanes on the northern edge.

THE WESTERN VEIL NEBULA, NGC 6960

RA 20h 46m, dec. +30° 46′

The Veil Nebula in Cygnus sits overhead in the summer. The brightest part, around 52 Cygni, is the Western Veil and is 1.5° in length. For the best overall view of the whole object use the minimum useful magnification together with averted vision and an OIII filter to improve the contrast. Experiment with higher powers to see if you can see some of the fine sinuous structure in the heart of this object. Ⓢ

MARTIN LEWIS X 8, GRAPHS BY PAUL WOTTON/REF: MARTIN LEWIS

Could Ceres really be a Kuiper Belt Object that has migrated into its current orbit? Dawn might be able to give us the answer

NEW DAWN ON Ceres

Govert Schilling looks ahead to Dawn's encounter with an asteroid that could possess more water than Earth

Next month, NASA's Dawn spacecraft will gently slip into orbit around Ceres, the largest asteroid in our Solar System. In 2011 and 2012, Dawn spent almost 14 months studying Ceres's smaller cousin, Vesta.

If the science results obtained at Vesta are any indication, astronomers can expect a bonanza of exciting new insights about Ceres in the months to come. Moreover, Dawn's arrival at Ceres will mark the start of the close-up examination of dwarf planets: four months later, on 14 July, New Horizons will fly past Pluto in the cold, outer reaches of the Solar System.

Ceres circles the Sun every 4.6 years in the wide gap between the orbits of Mars and Jupiter. In the late 19th Century, astronomers already believed a new planet might lurk there – an idea put forward in a 1772 book by German astronomer Johann Elert Bode.

Building on the work of Johann Daniel Titius, Bode described a mathematical sequence that predicted the sizes of the known planetary orbits, assuming the existence of an as-yet-unknown planet between Mars and Jupiter. When, in 1781, the newly discovered planet Uranus also turned out to abide to Bode's Law, astronomers became convinced that the gap between the fourth and fifth planets could not be empty.

In 1800, Hungarian astronomer and nobleman Baron Franz Xaver von Zach started a search programme, to be carried out by 24 astronomers all over Europe. In fact, the 'Himmelspolizei' (Celestial Police), as Von Zach called the initiative, was the first example of large-scale international cooperation in astronomy. One of the scientists asked to cooperate in the search was Giuseppe Piazzi, the 54-year-old director of the Palermo Observatory, on the north coast of Sicily.

The 'planet' in the gap

For some reason, Von Zach's letter never reached Piazzi, but while the other 23 celestial sleuths were scanning ▸

The huge impact that created this basin also blew chunks of Vesta into space

DAWN AT VESTA

Before Dawn set sail for Ceres, it spent 14 months orbiting the smaller asteroid Vesta. Vesta measures some 573x557x446km (it is markedly oblate) and it has a high-density, differentiated interior, comparable to the structure of larger terrestrial planets. In fact, some planetary researchers describe Vesta as a protoplanet: if there had been more small planetesimals around, it could have grown into an object with a size more similar to the Moon.

Dawn was at Vesta between July 2011 an September 2012. Its most remarkable findings are related to the huge impact basin at Vesta's south pole, named Rheasilvia. A dramatic collision with another large body chipped away part of Vesta's southern hemisphere, leaving this massive circular scar with a large central mountain behind. The impact all but shattered the asteroid: girdling its equator are giant ridges and trenches that formed in the aftermath of the collision. Impact debris – recognisable through its mineralogical composition, which is unique to Vesta – was strewn around the inner Solar System. In fact, five per cent of all meteorites on Earth are actually small fragments of Vesta.

In late 2014, planetary scientists published a detailed geological map, based on Dawn's data. Thanks this space probe, Vesta is now the best-known asteroid.

ALAMY, NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA X 2

Ceres (inset) was quickly found to be a large member of the Asteroid Belt; in fact, it accounts for one-thrid of the Belt's mass

▸ the skies with their telescopes in vain, Piazzi stumbled upon the new 'planet' by accident. It was the evening of 1 January 1801. He named it Ceres, after the Roman patron goddess of Sicily. A mere 20 years after the discovery of Uranus, the Solar System had gained yet another planet, bringing the number of known planets to eight. However, Ceres didn't enjoy its planetary status for long: it is now known to be the largest body in the asteroid belt, bearing minor planet number 1.

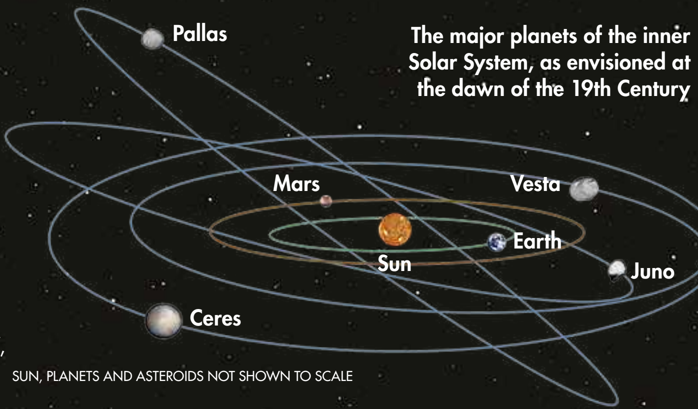
Despite its great distance, being a few hundred million kilometres away, astronomers have succeeded in calculating Ceres's diameter. It measures some 975x909km across, while its rotational period is nine hours and 4.5 minutes. Ceres is 80 per cent larger and 3.6 times more massive than the second-largest asteroid, Vesta. In fact, it contains about one-third of the total mass of the asteroid belt. Using the Hubble Space Telescope and the Keck Telescope, scientists have discovered some bright and dark regions on its surface; the largest dark 'spot' has unofficially been named Piazzi.

The two-orbit pioneer

The mass of Ceres has been derived from its minute gravitational perturbations on other asteroids. From the object's known mass and size, its density has been calculated at a pretty low 2.1g per cubic centimetre, suggesting a large fraction of ice – perhaps as much as 25 per cent, which would mean that Ceres contains more water than the Earth's oceans, albeit in frozen form. Indeed, spectroscopic observations have revealed the existence of hydrated (water-bearing) minerals on the dust-covered surface. And in January 2014,

POISED TO BE **A PLANET**

When Ceres, Pallas, Juno and Vesta were discovered in the first years of the 19th Century they were listed as the eighth, ninth, tenth and eleventh planets of the Solar System. William Herschel, who discovered Uranus in 1781, was the only one who suggested these small bodies belonged to a new class, for which he coined the term 'asteroids' – meaning 'star-like', a reference to their point-like appearance in a telescope.



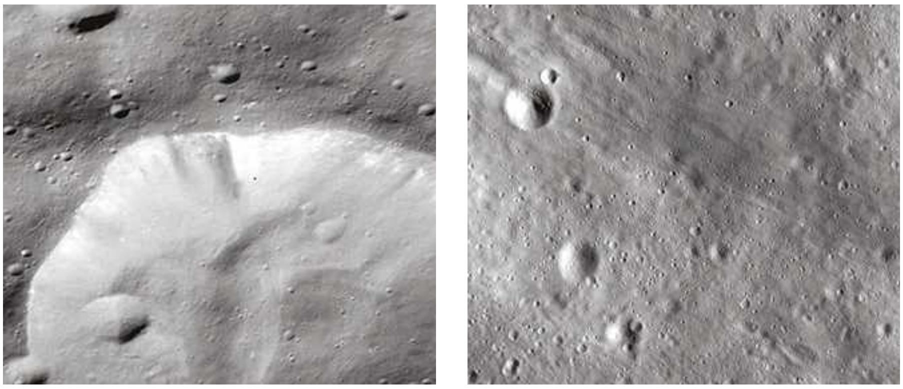
The major planets of the inner Solar System, as envisioned at the dawn of the 19th Century

Herschel may have simply disliked the idea of sharing his status of planet discoverer with others. But when more and more small bodies were found between the orbits of Mars and Jupiter in the mid-1800s, astronomers indeed reclassified them as 'minor planets' or asteroids. Neptune, discovered in 1846, became the eighth 'regular' planet. The demotion of Ceres, Pallas, Juno and Vesta was not unlike what happened to Pluto in 2006. When Pluto was discovered in 1930, it was regarded as the ninth planet, albeit a very small one in an unusual orbit. Only since the 1990s, when more and more ice dwarfs were found beyond the orbit of Neptune, did it become clear that Pluto was just one of the largest Kuiper Belt Objects. In August 2006, the International Astronomical Union (IAU) decided to strip Pluto of its undeserved planethood.

Together with a small number of other Kuiper Belt Objects, both Pluto and Ceres have officially been classified by the IAU as dwarf planets: they are large enough to be spherical under the influence of their self-gravity, but not massive enough to have cleared their orbital regions of smaller objects.

ESA/ATG MEDIALAB, NASA/ESA/J. PARKER (SOUTHWEST RESEARCH INSTITUTE) P. THOMAS (CORNELL UNIVERSITY) L. MCFADDEN (UNIVERSITY OF MARYLAND/COLLEGE PARK) AND M. MUTCHLER AND Z. LEVAY (STSCI), NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA X 2, NASA/KSC, NASA/JPL-CALTECH

Dawn's ion engine is the stuff of science fiction, relying on electrically excited xenon atoms: you can see it on the bottom left of the spacecraft



▲ **Dawn's cameras were able to capture stunning close-up images of Vesta during its flyby**

the European infrared Herschel Space Observatory discovered localised plumes of water vapour – something that has never before been witnessed on any asteroid. Little wonder, then, that planetary scientists are eagerly looking forward to the arrival of the Dawn spacecraft.

Launched on 27 September 2007, Dawn flew past Mars on 17 February 2009 and entered orbit around Vesta on 15 July 2011. After studying this intriguing 'protoplanet' for over a year (see 'Dawn at Vesta', page 43) it departed, setting off for Ceres. It's the first time in the history of space exploration that one craft will orbit two separate celestial bodies during its mission – a feat made possible by Dawn's versatile ion propulsion engine, which uses the minute thrust of electrically accelerated xenon atoms to navigate the craft through interplanetary space.

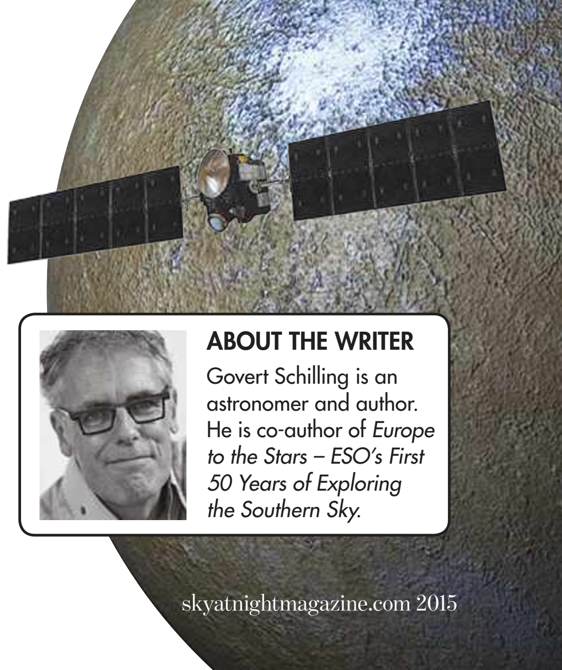
Tucked between the huge solar arrays – which have a total span of almost 20m – is the Dawn spacecraft itself. It is almost as large as two queen-size beds on top of each other and has a 1.5m high-gain antenna for radio communication with Earth. A German-built camera will image Ceres in seven different colour bands, while the Italian visible and infrared mapping spectrometer studies the composition and thermal properties of the dwarf planet's surface. An American gamma-ray and neutron detector will determine the relative abundances of chemical elements. Finally, using spacecraft telemetry, astronomers will learn about Ceres's rotational properties.

Ceres the reservoir

On 6 March, Dawn will be captured in Ceres's gravitational field. But it won't start orbiting the dwarf planet right away. First, the spacecraft will fly out to a distance of some 75,000km, then turn around using its ion engine and finally manoeuvre itself into a polar orbit around 23 April. In November 2015, the spacecraft will be moved into a low-altitude mapping orbit, at a mere 375km above the surface. The original orbit insertion plan was much simpler, but mission controllers had to redesign the procedure from scratch after an energetic cosmic ray caused temporary havoc to the engine's electronics on 14 September. Since ion engines work so slowly, the glitch had a huge impact on Dawn's thrust timeline.

Dawn's exploration of Ceres will yield valuable insights into the early evolutionary history of the terrestrial planet. Will Piazzi's planet indeed turn out to be the largest water reservoir in the inner regions of the Solar System? And will the deuterium (heavy hydrogen) abundance of this water match the value in the Earth's oceans? If so, it would suggest that our planet's water could have been delivered by asteroids, not by comets – after all, measurements by the European Space Agency's Rosetta mission have shown that the deuterium abundance in comet 67P/Churyumov-Gerasimenko is three times as high as the terrestrial value.

Alternatively, if Ceres also has a high deuterium fraction, this could imply that it was born in the far reaches of the Solar System, way beyond Neptune's orbit, and that it migrated into the asteroid belt by gravitational interactions of the planets some four billion years ago – a scenario suggested by planetary scientist Bill McKinnon of Washington University. If that turns out to be the case, Ceres would be the first Kuiper Belt Object to be studied up close – a few months before New Horizon's arrival at Pluto. Ⓢ



ABOUT THE WRITER

Govert Schilling is an astronomer and author. He is co-author of *Europe to the Stars – ESO's First 50 Years of Exploring the Southern Sky.*

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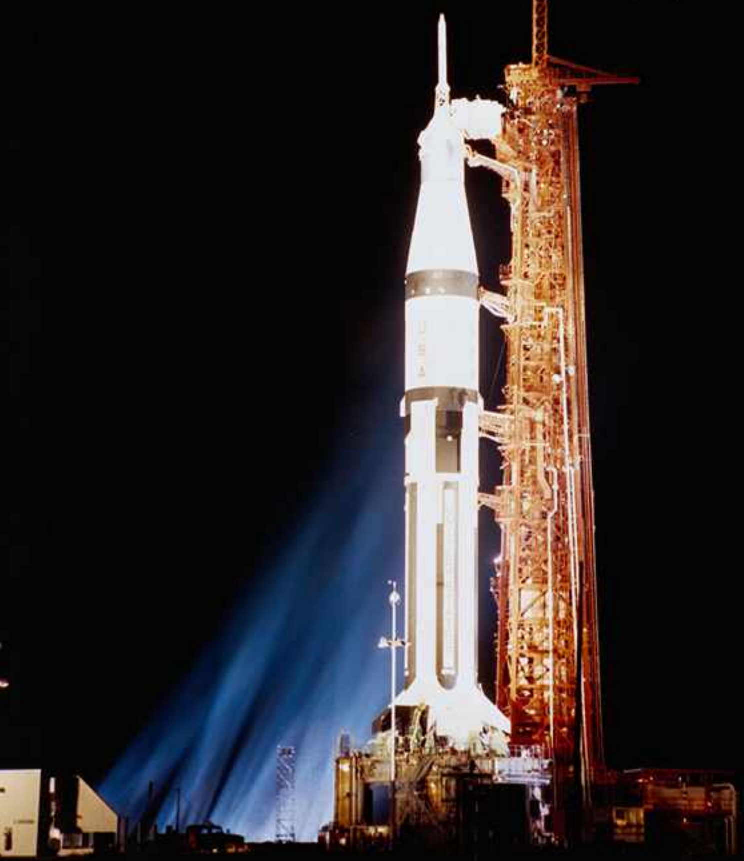

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PLUS

Stephen Tonkin's **BINOCULAR TOUR**

Turn to page 58 for six of this month's best binocular sights

The Sky Guide February

The Mare Orientale is one of the most impressive lunar impact basins. Surrounded by rings of mountains, the sea is tantalisingly out of sight for most of the time. This month, the Moon's libration will bring part of it briefly into view.

PETE LAWRENCE

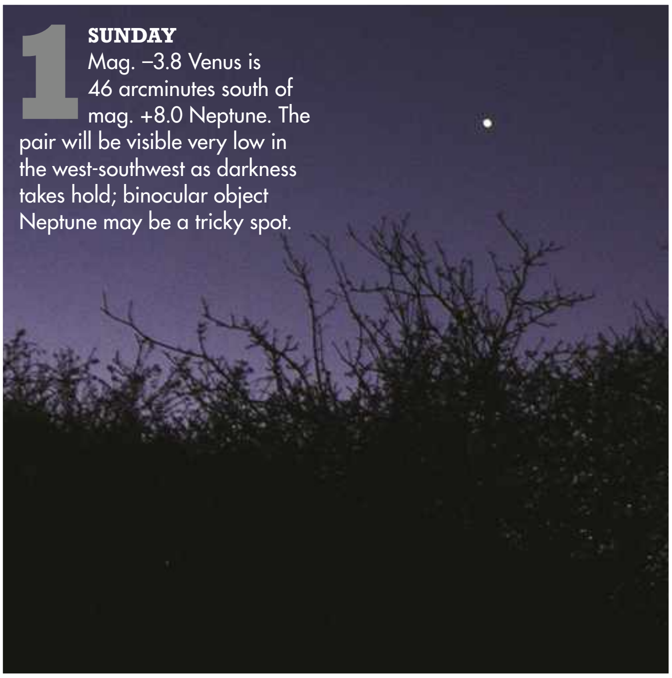
Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity



1 SUNDAY
Mag. –3.8 Venus is 46 arcminutes south of mag. +8.0 Neptune. The pair will be visible very low in the west-southwest as darkness takes hold; binocular object Neptune may be a tricky spot.

3 TUESDAY
The full Moon occults mag. +4.3 Acubens (Alpha (α) Cancri) tonight. The event is visible north of a line running from the south of Northern Ireland across the north of the Isle of Man, north of Windermere and south of Middlesbrough. View from 19:30 UT.

4 WEDNESDAY
The near-full Moon is around 6° southwest of mag. –2.4 Jupiter in the eraly hours. Despite the lunar glare, Jupiter's brilliance means that the planet is easy to see. These events make great photographic targets.

9 MONDAY ▶
Jovian moon Io is partially eclipsed by the shadow of fellow moon Ganymede between 21:05:57 UT and 21:12:56 UT. The main darkening part of the eclipse occurs from 21:07:40 UT until 21:11:13 UT, between which Io should appear to dim.

15 SUNDAY ▶
The Beehive Cluster, M44 in Cancer, is nearly 60° up and due south at 23:00 UT, with Jupiter lying 9° east-southeast. Binoculars will show the cluster well. Look about 8° south of M44 using binoculars to locate the dimmer ancient open cluster M67.

16 MONDAY
Giant Jovian moon Ganymede will partially occult fellow moon Io between 23:18:59 UT and 23:24:14 UT. This event will be followed by Ganymede's shadow partially eclipsing Io between 23:52:30 UT and 23:59.26 UT. See page 50.

19 THURSDAY
Jupiter's moon Io partially occults Ganymede between 23:48:26 UT and 23:54:34 UT. Ganymede's brightness should drop a little. Io's shadow will transit Ganymede's disc (an annular eclipse) between 00:35:05 UT and 00:43:17 UT on the 20th. See page 50.

20 FRIDAY
Mag. +1.3 Mars, mag. –3.8 Venus and a slender 4%-lit waxing crescent Moon form a tight pattern low in the west after sunset. See page 51.

22 SUNDAY
The backward question mark pattern of stars that represents the head of Leo can be seen around 50° up and due south around midnight. Mag. +1.4 star Regulus (Alpha (α) Leonis) is the punctuation dot of the question mark. The pattern forms a familiar asterism known as the Sickle.

23 MONDAY ▶
The Leo Triplet of galaxies is well placed in darkness at the moment. The three member galaxies – M65, M66 and NGC 3628 – can be seen with a small telescope. They are located in the back legs of Leo, 50° up and due south at 01:20 UT.

PETE LAWRENCE X 7

6 ◀ **FRIDAY**

Jupiter is at opposition today. The weeks around opposition represent the best time to observe this dynamic planet as it now appears at its biggest and brightest for the year.

13 **FRIDAY** ▶

The 38%-lit waning crescent Moon lies 3.5° east of Saturn. Both are visible in the morning sky at around 06:00 UT.

17 **TUESDAY**

The 4%-lit waning crescent Moon lies 3° north of mag. +0.3 Mercury in the morning sky. Spot the pair from around 06:30 UT, low in the southeast.

18 **WEDNESDAY**

The intensely bright star low down in the south at around 21:00 UT is Sirius, the brightest star in the entire night sky. From the UK, the light of Sirius has to pass through a thick and turbulent atmospheric layer, which can cause it to flash vibrant colours.

21 ◀ **SATURDAY**

This evening and tomorrow evening, mag. +1.3 Mars and mag. –3.8 Venus are separated by around 0.5° low in the western sky as darkness falls. See page 51 .

26 **THURSDAY**

Outer Galilean moon Callisto will partially occult Europa between 20:26:08 UT and 20:30:07 UT. See page 50.

27 **FRIDAY**

The shadow of Galilean moon Io will travel across the face of Ganymede between 03:31:22 UT and 03:40:33 UT. Ganymede's brightness will dip by a small amount during this annular eclipse. See page 50.

What the team will be observing in February

Pete Lawrence "Venus is back in the evening twilight sky and its close encounter with Mars should make for a fabulous imaging opportunity. I think a few trips down to the beach for a really flat horizon will be in order!"

Paul Money "With Jupiter at opposition on 6 February I'll be trying to get my best views and images of it and its four Galilean moons using my 7-inch Maksutov and webcam."

Steve Marsh "I once got a great shot of Venus and the crescent moon mere degrees apart. I think this month I'll try the more challenging pairing with Saturn on the 13th."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

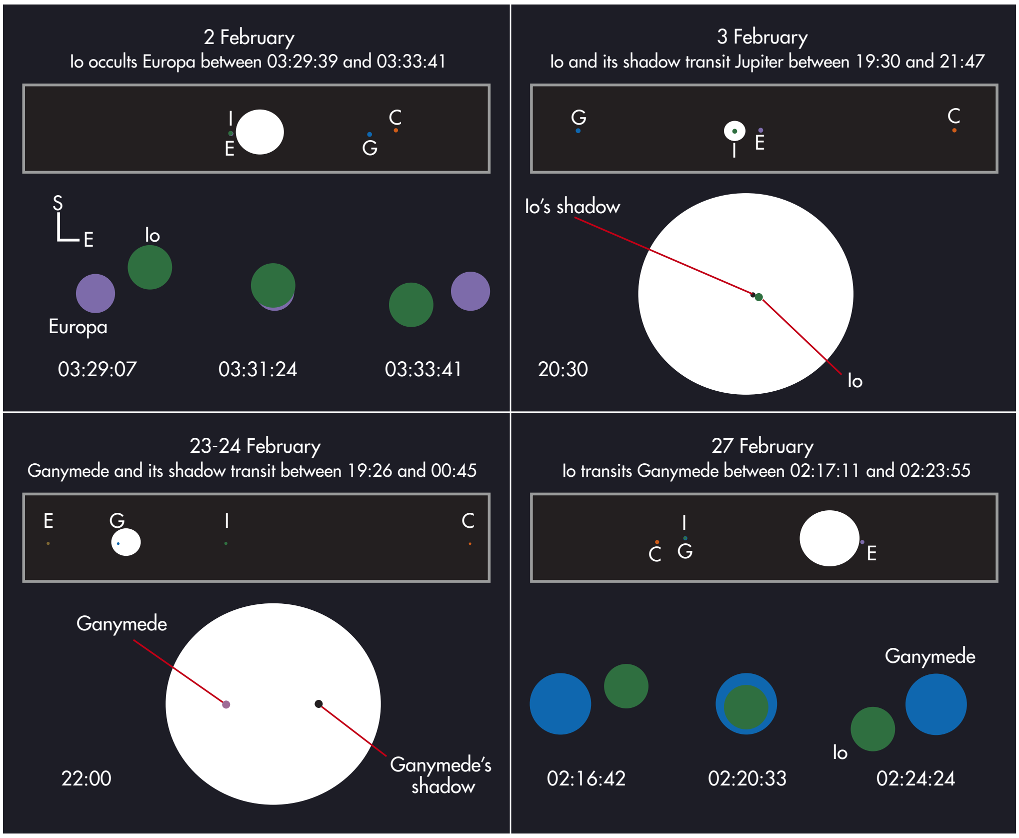
If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

DON'T MISS...

3 top sights

Jupiter's moon show continues

WHEN: 2, 3, 23/24 and 27 February, times as specified



Some Jovian moon events are over in minutes, so it's best to allow plenty of time to set up beforehand

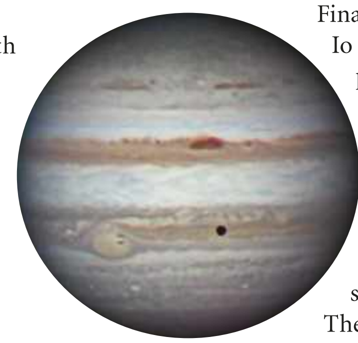
JUPITER REACHES OPPOSITION on 6 February and experiences an equinox, the time that the Sun is on its equatorial plane, on the 5th. This orientation is interesting because from Earth, although the alignment isn't precisely the same, it's similar enough to allow us to see some interesting interactions between the planet and its four largest moons as well as some rather special mutual events that can occur between the moons themselves.

The four moons in question are Io, Europa, Ganymede and Callisto, collectively known as the Galilean Moons. To start, on 2 February innermost moon Io will pass in front of the second moon out, Europa. This is a large partial occultation – Io almost, but not quite, covering Europa.

Though a small telescope it will be possible to see the moons approach one another in the lead up to the occultation; at 03:25 UT, it will be hard to separate the pair. The occultation begins at 03:29:39 UT, with maximum coverage at 03:31:24 UT. At this point, both moons will appear as one even through a large scope. The event ends almost as quickly as it begins at 03:33:08 UT.

On 3 February, there's a rather lovely regular interaction between Io and Jupiter. Look at the planet at 19:00 UT and you'll see the dot of Io very close to Jupiter's eastern limb. The Great Red Spot should also be visible at this time, closer to the west limb. At 19:25 UT, as Io appears to be virtually touching the limb, the moon's shadow will make its presence known on Jupiter's disc, close to Io itself. Io officially begins to transit Jupiter at 19:30 UT and – being so close to opposition – the moon and its shadow appear as a tight pair as they cross Jupiter's globe. The shadow leaves the disc at 21:43 UT, closely followed by Io at 21:47 UT.

By the 23rd, Jupiter will have moved slightly away from opposition and this is shown by a lovely dual transit of giant Ganymede and its shadow. After opposition Ganymede leads the way, passing onto the disc at 19:26 UT. The increased Sun angle means that its shadow takes longer to appear, passing onto Jupiter's globe at 21:07 UT. Ganymede exits off the west limb at 23:03 UT, with its shadow following suit at 00:45 UT on 24 February.



The shadows of Io and Ganymede can be seen transiting this month

Finally, on the 27th, Io and Ganymede put on another show, the smaller moon attempting to occult its larger stablemate. The alignment is almost perfect but, with a smaller disc, Io is unable to fully cover Ganymede and ends up passing inside the larger moon's boundary in an annular occultation or transit. This event starts at 02:17:11 UT and ends at 02:23:55 UT, with maximum annularity occurring at 02:20:33 UT.

NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.

PETE LAWRENCE X4

The Mare Orientale tilts into view

WHEN: 10-16 February

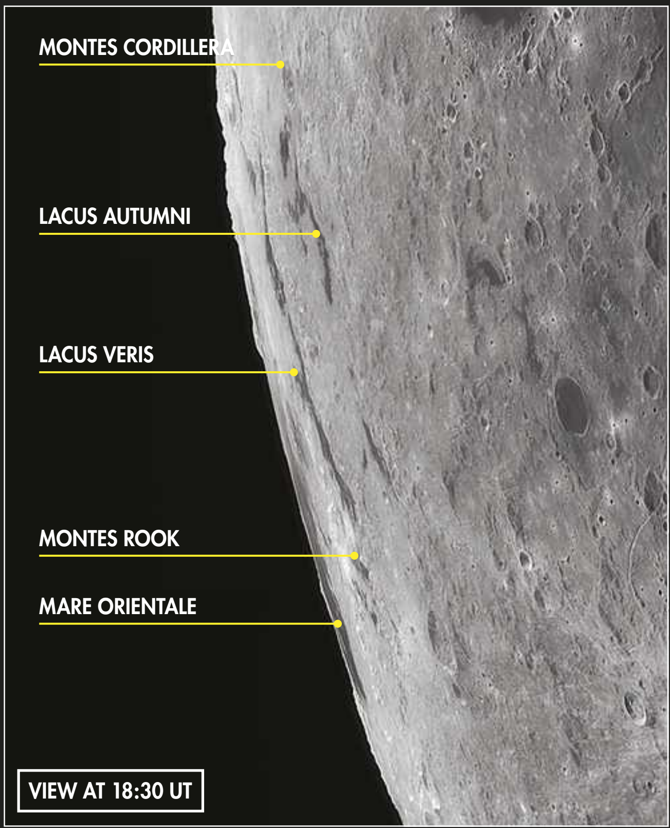
FROM EARTH WE can always see 50 per cent of the Moon's globe, but it isn't always the same 50 per cent every night. Variations in the Moon's orbital speed caused by the fact that its orbit is an ellipse rather than a circle, combined with a tilt relative to the plane of Earth's orbit around the Sun, means that over time we get to see up to an extra nine per cent of lunar real estate due to 'wobbling'.

The effect is called libration and the regions that rock and roll in and out of view are known as the libration zones. Unlike the features that are more central to the Moon's Earth-facing disc, those that exist in the libration zones are at times well presented and at others completely hidden from view.

A tantalising feature that lies in the southwest libration zone is the Mare Orientale, or the Eastern Sea. This lunar sea is surrounded by two distinct rings of mountains, the outer one measuring a whopping 900km across.

Seen head-on this feature would look like a bullseye, but from Earth our view is so heavily foreshortened that it's hard to make out the mare's true form. From 10-16 February, however, libration will present a favourable view of the Mare Orientale, with the best libration occurring on the 13th and 14th.

The mare itself is roughly circular, measuring 300km across. It's surrounded by Montes Rook, the inner mountain range. Within this formidable 6km-high, 600km-diameter ring lies the dark lava 'lake' known as Lacus Veris, or the Lake of Spring. With the region under bright sunlight, the dark lava and contrastingly bright mountain peaks make good features to look out for and these can help make sense of the region.



▲ Use the dark lakes and tall peaks to find your way around the mare

The outer 900km mountain ring is formed by the Montes Cordillera and, like the Montes Rook, it also contains a dark lava lake. Lacus Autumni, the Lake of Autumn, is visible inside its northeast boundary.

Mars and Venus

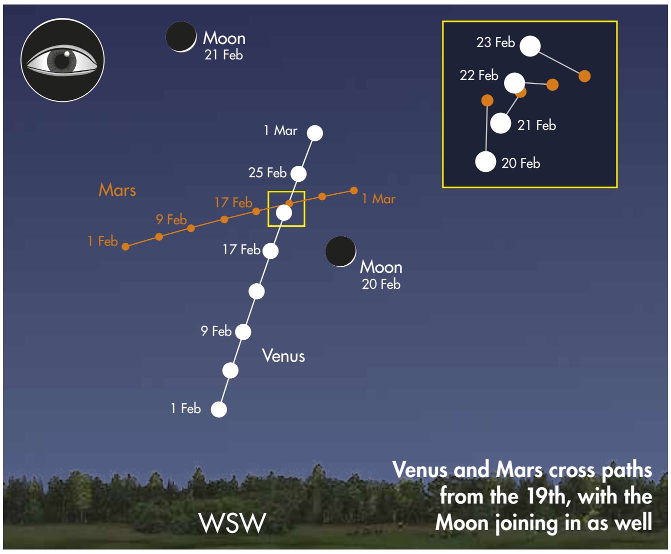
WHEN: 19-23 February, 19:00 UT

LOOK LOW TO the west-southwest after sunset during February and you should be able to see brilliant Venus shining back at you. The brightest of all the planets, Venus is slowly but surely improving in position as its apparent separation from the Sun increases.

Much less obvious is Mars. This month, as mag. –3.8 Venus increases its angular separation from the Sun, it'll appear to pass really close to the mag. +1.3 Red Planet.

On 1 February, both planets will be separated by 9.5°, Venus being closer to the Sun and lower down after sunset. Venus will appear to close in on Mars and on 19 February both planets will be just over 1° apart, setting nearly three hours after the Sun.

On the 20th the separation will have decreased to 0.75° and a slim (4% lit) waxing crescent Moon will lie 4° below and right of the pair. On the 21st, the now 11%-lit waxing crescent Moon will appear 10° above and left of the planets. On this evening, Venus and Mars will be just 28 arcminutes apart – this is approximately the same apparent diameter as the Moon. A similar separation of 29 arcminutes occurs on the 23rd with both planets parting company rapidly on subsequent evenings.



Venus and Mars cross paths from the 19th, with the Moon joining in as well

NEED TO KNOW

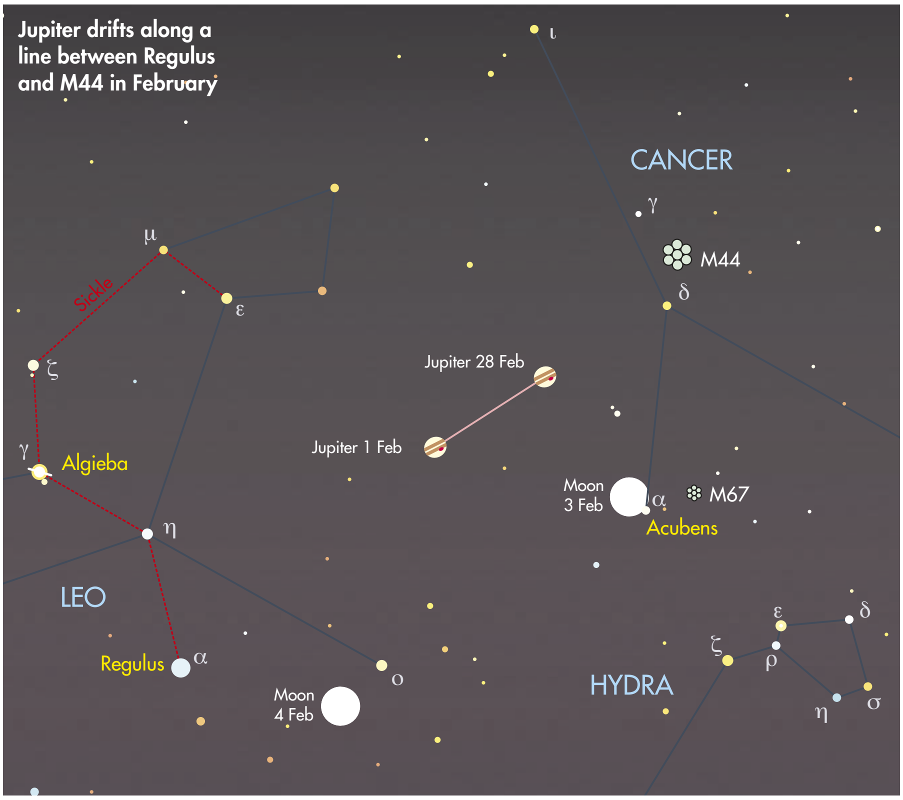
The size of objects in the sky and the distances between them are measured in degrees. The width of your little finger at arm's length spans about 1°.

The planets

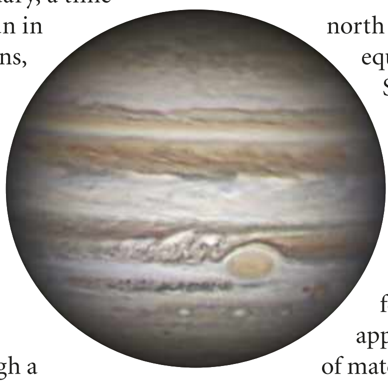
PICK OF THE MONTH

JUPITER

BEST TIME IN FEBRUARY:
6 February, 00:30 UT
ALTITUDE: 53°
LOCATION: Cancer
DIRECTION: South
RECOMMENDED EQUIPMENT:
3-inch or larger scope
FEATURES OF INTEREST:
Atmospheric features, Great Red Spot, Galilean Moons



THERE'S NO MISTAKING magnificent Jupiter this month as the planet comes to opposition on 6 February, a time when it's opposite the Sun in the sky. When this happens, Jupiter's apparent diameter reaches its largest value for the year, which for 2015 is 45.3 arcseconds. It's also at its brightest, shining away at mag. –2.6. Although opposition occurs on the 6th, through a telescope the view of the planet is optimal for a number of weeks either side of this date.



The Great Red Spot is visible in a 4-inch scope in good conditions

A small telescope will show plenty of detail on Jupiter's disc. The most obvious features are the two dark belts that run north and south of the equator, known as the South Equatorial Belt (SEB) and North Equatorial Belt (NEB). The region between them is often filled with interesting features such as festoons. These typically appear as blue-grey swirls of material, draped into the equatorial zone.

Dark elongated barges and spots may also be seen with a 6-inch or larger scope. The famous Great Red Spot is somewhat easier. Nestled into the southern edge of the SEB, it can be glimpsed under steady conditions with a 4-inch telescope.

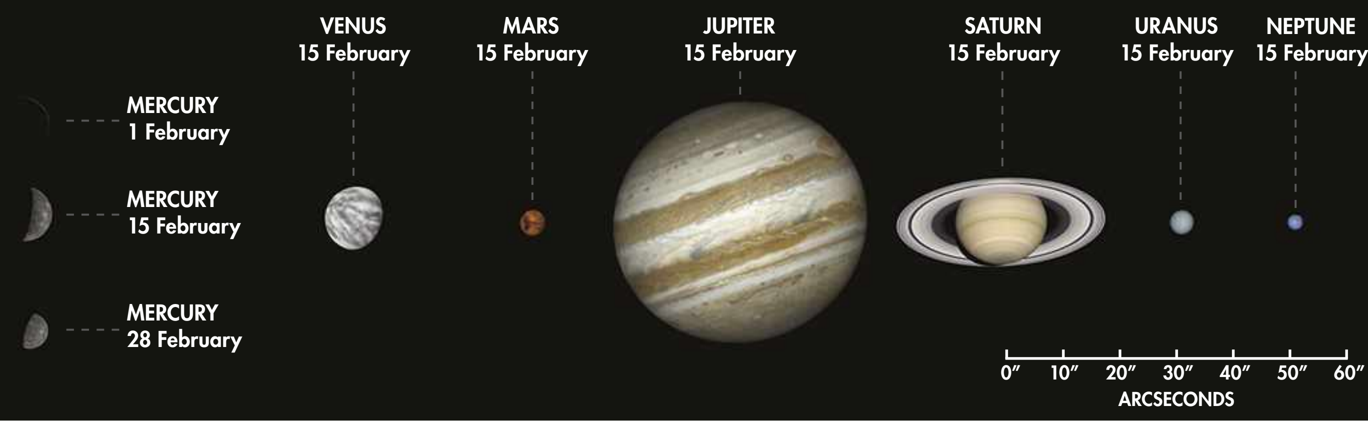
Other belts and features outside of the equatorial region can be seen, but these are often harder to pick out. The trick here is to really let your eyes get used to the scene. Use as high a magnification as the conditions will stand. A big, fuzzy planet is yields less detail than a small but steadier looking one.

The planet currently sits on the line joining mag. +1.4 Regulus (Alpha (α) Leonis) to the Beehive Cluster, M44 in Cancer. At the start of the month, it is located roughly halfway along this line, but moves westward towards M44 as the month progresses. A full Moon sits 6° south of Jupiter on the 3rd.

PETE LAWRENCE X 3

THE PLANETS IN FEBRUARY

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



MERCURY

BEST TIME IN FEBRUARY: 17 February, 07:00 UT
ALTITUDE: 4° (low)
LOCATION: Capricornus
DIRECTION: Southeast

Mercury is a morning object but not well placed due to the shallow angle made by the ecliptic in the morning sky at this time of year. The planet should be visible from the 6th onwards. It reaches an impressive greatest western elongation of 26.7° on the 24th, but as it rises less than an hour before the Sun its mag. +0.2 dot will be tricky to see – look for it very low in the southeast. On the 17th, the 4%-lit crescent Moon is 2.5° north of the planet.

VENUS

BEST TIME IN FEBRUARY: 28 February, 18:00 UT
ALTITUDE: 22°
LOCATION: Pisces
DIRECTION: West-southwest

The appearance of Venus is improving with each passing day. It's now visible after sunset low in the west-southwest. At around mag –4.0, it shines clearly even through bright twilight. If you can get a view of it through a scope, Venus shows a large gibbous phase, its illumination falling from 92% on the 1st to 86% on the 28th. The disc is quite small for Venus, growing from 11 to 12 arcseconds during the month. Between the 19th and 23rd Venus and mag. +1.3 Mars have a close encounter that is easy to spot (see page 51).

MARS

BEST TIME IN FEBRUARY: 21 February, 18:00 UT
ALTITUDE: 19°
LOCATION: Pisces
DIRECTION: West-southwest

Mars is an evening object, moving from Aquarius into Pisces throughout February. The planet is currently on the far side of its orbit from Earth. Consequently, through a telescope it is just 4 arcseconds across and relatively dim at around mag. +1.3. The headline act with Mars this month is its encounter with Venus on 19-23 February. See page 51.

SATURN

BEST TIME IN FEBRUARY: 28 February, 05:15 UT
ALTITUDE: 17°
LOCATION: Scorpius
DIRECTION: Just east of south

Another morning object, Saturn just manages to culminate in darkness at the end of the month, but from the UK it is low down. This makes getting a sharp view of it tricky as the thick layer of atmosphere close to the horizon distorts fine detail. Saturn's rings are currently very open, the planet's north pole being tilted towards us by 25°. On the 13th, the 38%-lit crescent Moon is 2.5° east of the planet, visible around 03:30 UT.

URANUS

BEST TIME IN FEBRUARY: 1 February, 19:00 UT
ALTITUDE: 30°
LOCATION: Pisces
DIRECTION: Southwest

Mag. +5.9 Uranus can be seen south of the 4th-magnitude stars Epsilon (ε) and Delta (δ) Piscium. An 11%-lit crescent Moon lies around 2° from Uranus on the 21st, visible low in the west from 20:00 UT. Venus is heading up towards Uranus and due for a seriously close encounter in early March.

NEPTUNE

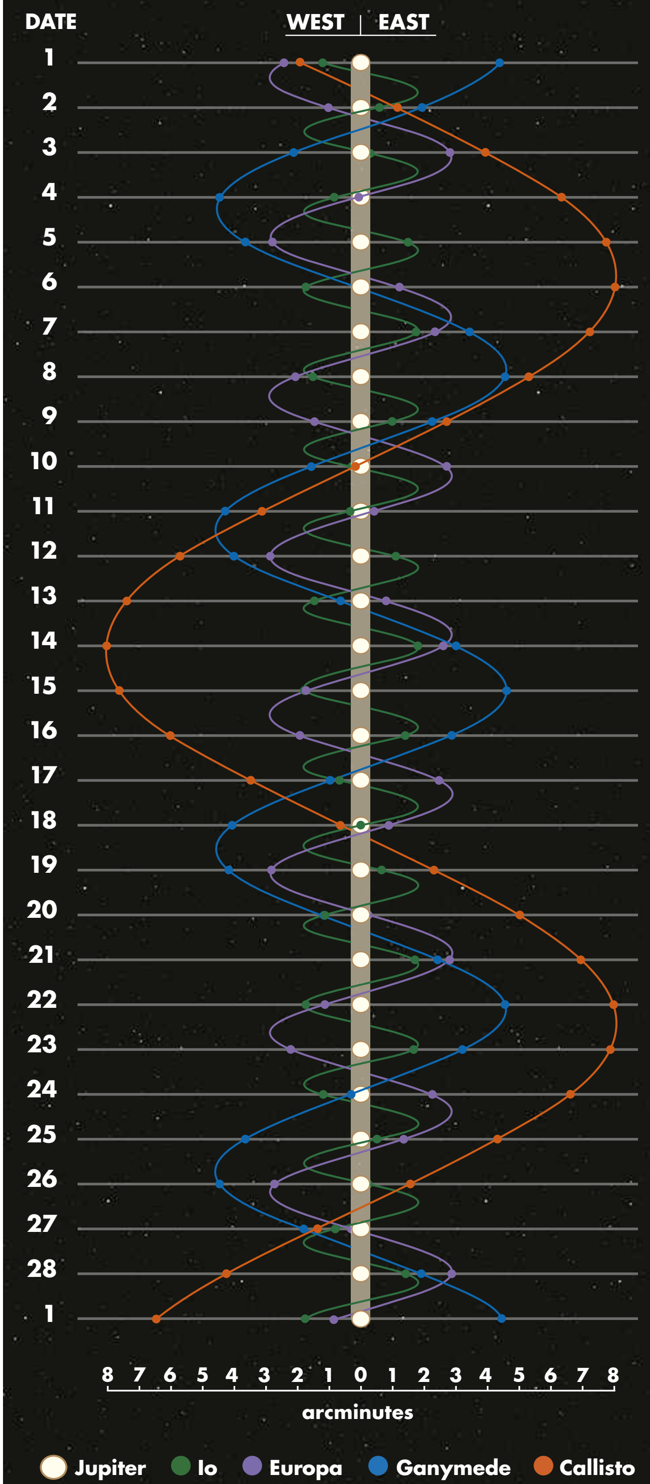
BEST TIME IN FEBRUARY: 1 February, 18:00 UT
ALTITUDE: 9° (low)
LOCATION: Aquarius
Direction: West-southwest

Neptune is an 8th-magnitude binocular object low in the west-southwest at the start of the month. It is soon lost from view as it heads for conjunction with the Sun on 25 February.

See what the planets look like through your telescope with the **field of view calculator** on our website at:
http://www.skyatnightmagazine.com/astronomy-tools

JUPITER'S MOONS
February

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
	GALAXY
	OPEN CLUSTER
	GLOBULAR CLUSTER
	PLANETARY NEBULA
	DIFFUSE NEBULOSITY
	DOUBLE STAR
	VARIABLE STAR
	THE MOON, SHOWING PHASE
	COMET TRACK
	ASTEROID TRACK
	STAR-HOPPING PATH
	METEOR RADIANT
Circlet	ASTERISM
	PLANET
	QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

N E S W — COMPASS AND FIELD OF VIEW

MILKY WAY

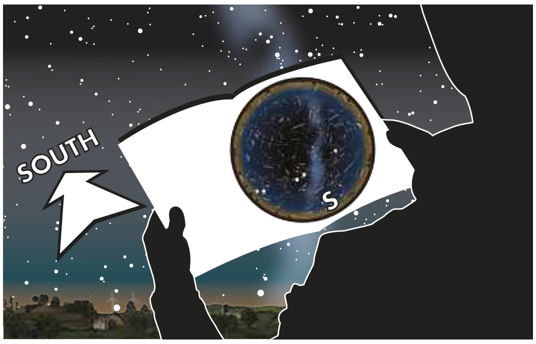
WHEN TO USE THIS CHART

1 FEBRUARY AT 00:00 UT
15 FEBRUARY AT 23:00 UT
28 FEBRUARY AT 22:00 UT

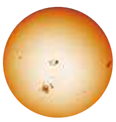
On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.



THE SUN IN FEBRUARY*



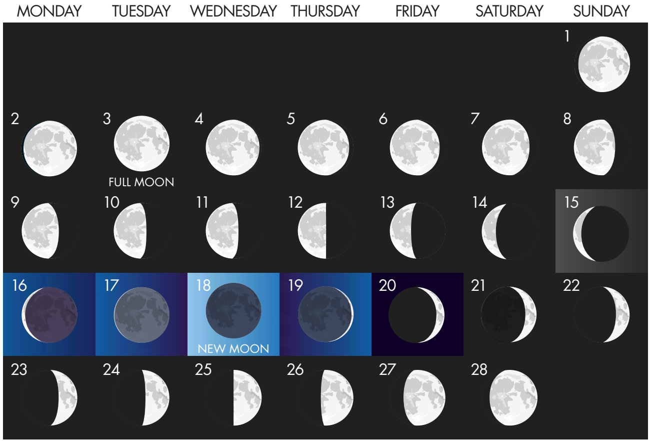
DATE	SUNRISE	SUNSET
1 Feb 2015	07:56 UT	16:52 UT
11 Feb 2015	07:37 UT	17:12 UT
21 Feb 2015	07:17 UT	17:32 UT
3 Mar 2015	06:54 UT	17:51 UT

THE MOON IN FEBRUARY*

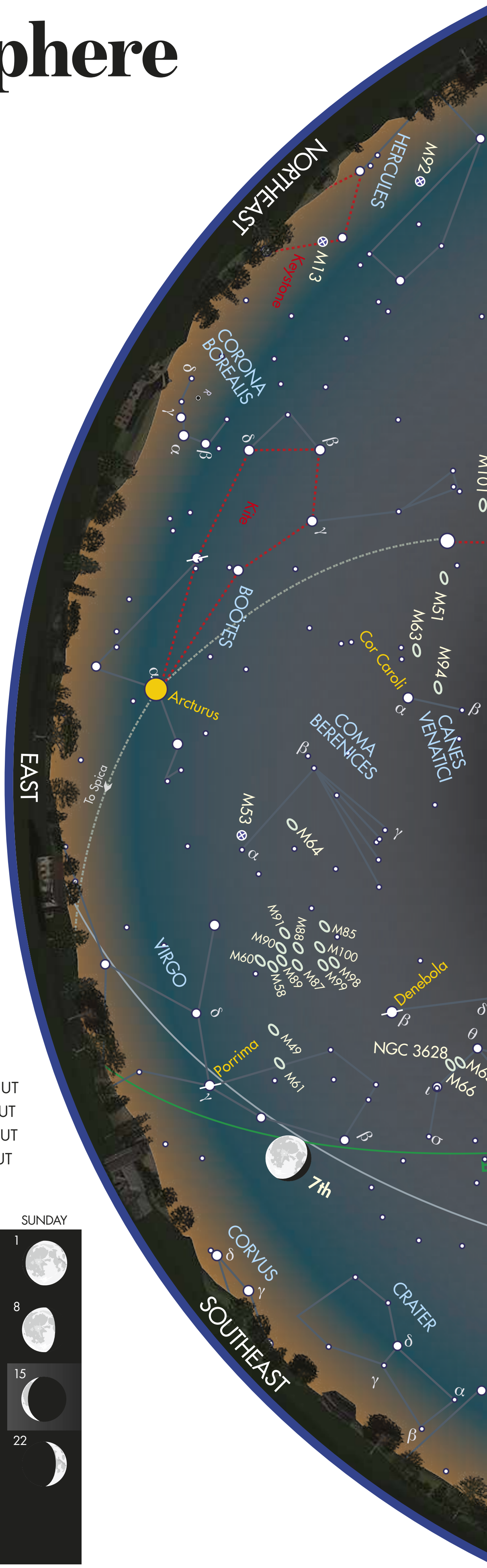
MOONRISE TIMES

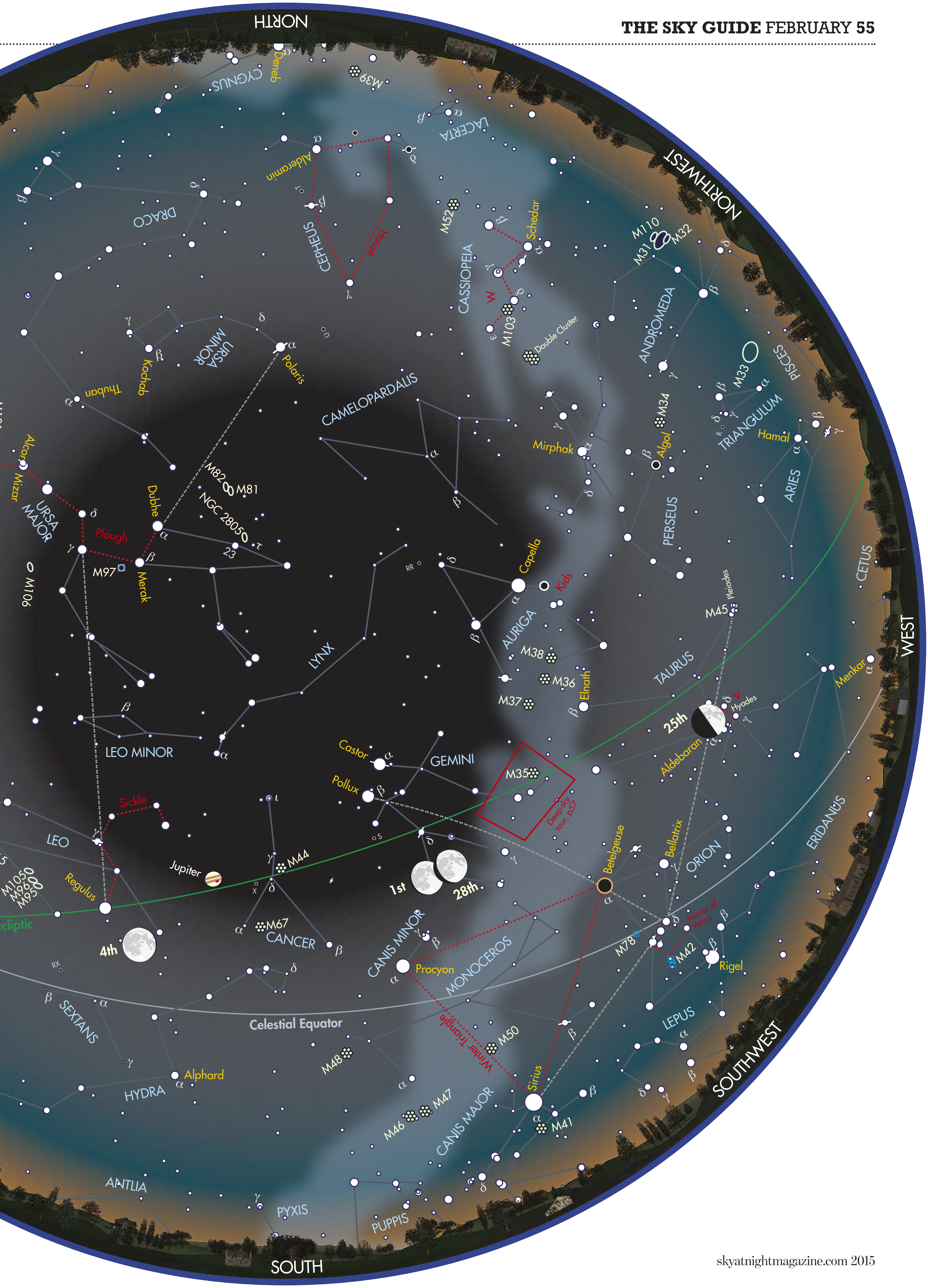
1 Feb 2015, 14:53 UT	17 Feb 2015, 06:06 UT
5 Feb 2015, 19:02 UT	21 Feb 2015, 08:13 UT
9 Feb 2015, 23:19 UT	25 Feb 2015, 10:23 UT
13 Feb 2015, 02:34 UT	1 Mar 2015, 13:47 UT

*Times correct for the centre of the UK



MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
						1
2	3 FULL MOON	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18 NEW MOON	19	20	21	22
23	24	25	26	27	28	

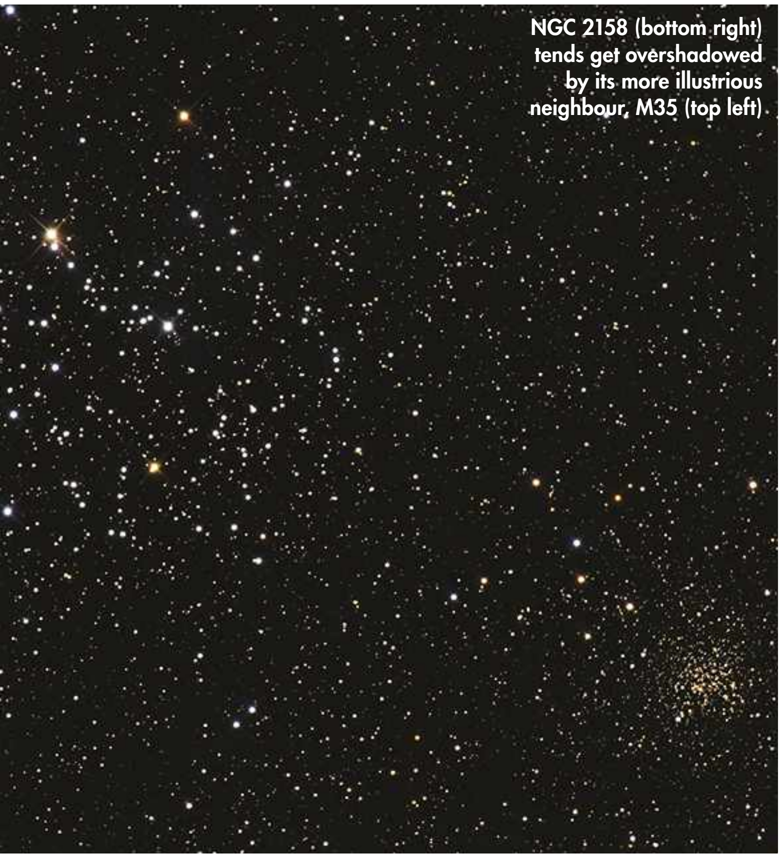



NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
CYGNUS
Deneb
M39
LACERTA
Alderamin
CEPHEUS
House
DRACO
M52
Schedar
CASSIOPEIA
W
M103
Double Cluster
M110
M31
M32
ANDROMEDA
M33
PISCES
URSA MINOR
Kochab
Thuban
Polaris
CAMELOPARDALIS
M34
TRIANGULUM
Hamal
Mirphak
Algol
ARIES
Alcor
Mizar
URSA MAJOR
M82
M81
NGC 2805
Dubhe
Plough
Merak
M97
M106
PERSEUS
Capella
Kids
AURIGA
CETUS
M45
Pleiades
LYNX
M38
M36
M37
Elnath
TAURUS
Menkar
Hyades
25th
Aldebaran
LEO MINOR
Castor
Pollux
GEMINI
M35
Deep-sky tour, p57
Sickle
LEO
M105
M96
M95
Regulus
Jupiter
M44
1st
28th
Betelgeuse
Bellatrix
ORION
ERIDANUS
Ecliptic
4th
M67
CANCER
CANIS MINOR
Procyon
MONOCEROS
Mirror of Venus
M78
M42
Rigel
SEXTANS
Celestial Equator
Winter Triangle
M50
LEPUS
M48
Alphard
HYDRA
Sirius
M47
M46
CANIS MAJOR
M41
ANTLIA
PYXIS
PUPPIS

Deep-sky tour

Delve deep into Gemini and the delights nestling around the foot of the twin Castor

☑ Tick the box when you've seen each one



NGC 2158 (bottom right) tends get overshadowed by its more illustrious neighbour, M35 (top left)

1 M35

M35 is a distinctive 5th-magnitude open cluster lying off the curved foot of the twin (not the star) named Castor in Gemini. It marks the right-angle in a triangle it forms with mag. +3.3 Propus (Eta (η) Geminorum) and mag. +4.2 1 Geminorum, and is a magnificent sight in a telescope of any size. The brightest central region measures around 0.5° across and appears to be asymmetrical. At this size, a wide-field eyepiece will give the best views. There are a number of lovely strings of stars visible here, curving elegantly across the cluster's core. The central region also appears to have some noticeable gaps. A 12-inch scope fitted with a low power, wide-field eyepiece reveals about 200 cluster stars. ☐ **SEEN IT**

2 NGC 2158

Located 24 arcminutes southwest of M35's centre is fainter and more compact open cluster NGC 2158. At mag. +8.6 and just 6 arcminutes across, it gets overshadowed by its more dramatic neighbour, appearing as nothing more than a blurry smudge through apertures smaller than 8 inches. In 8- to 10-inch scopes, approximately 40-50 stars can be seen on the threshold of visibility. The cluster has a central condensation resembling the appearance of a small globular. Although it may look less impressive than M35, there is good reason for this: M35 is estimated to lie 2,800 lightyears from Earth, while NGC 2158 is far more distant at 11,000 lightyears. ☐ **SEEN IT**

3 IC 2157

Approximately 0.5° northwest of NGC 2158 is an open cluster of similar brightness known as IC 2157. Listed at mag. +8.4, IC 2157 is marginally larger than NGC 2158 at 7 arcminutes across. Small telescopes tend to show it as a milky smudge, but a 10-inch scope or larger resolves around a dozen stars hovering around the mag. +10.0 to +12.0 mark. The cluster is less distinct than NGC 2158, so it's best to start at low magnification; this reveals its presence as a slight concentration against the background stars. Once found, increase the magnification to show the stars sitting at the cluster's core. ☐ **SEEN IT**

4 COLLINDER 89

Collinder 89, resting 2° east of M35, is another large open cluster at the foot of the twin Castor. Despite having the same mag. +5.7 brightness as its neighbour, Collinder 89 is less obvious because it covers a larger area of 1°, double that of M35. Consequently, a low-power eyepiece is essential here. The rich Milky Way background camouflages this sparse object well. The best way to locate it is to use Propus and mag. +2.9 Tejat Posterior (Mu (μ) Geminorum). Find the mid-point between these two stars and head north by about half the distance between them. A group of three mag. +6.5 to +7.0 stars marks the cluster's eastern boundary, with two 6th-magnitude stars to the northwest marking the cluster's western edge. ☐ **SEEN IT**

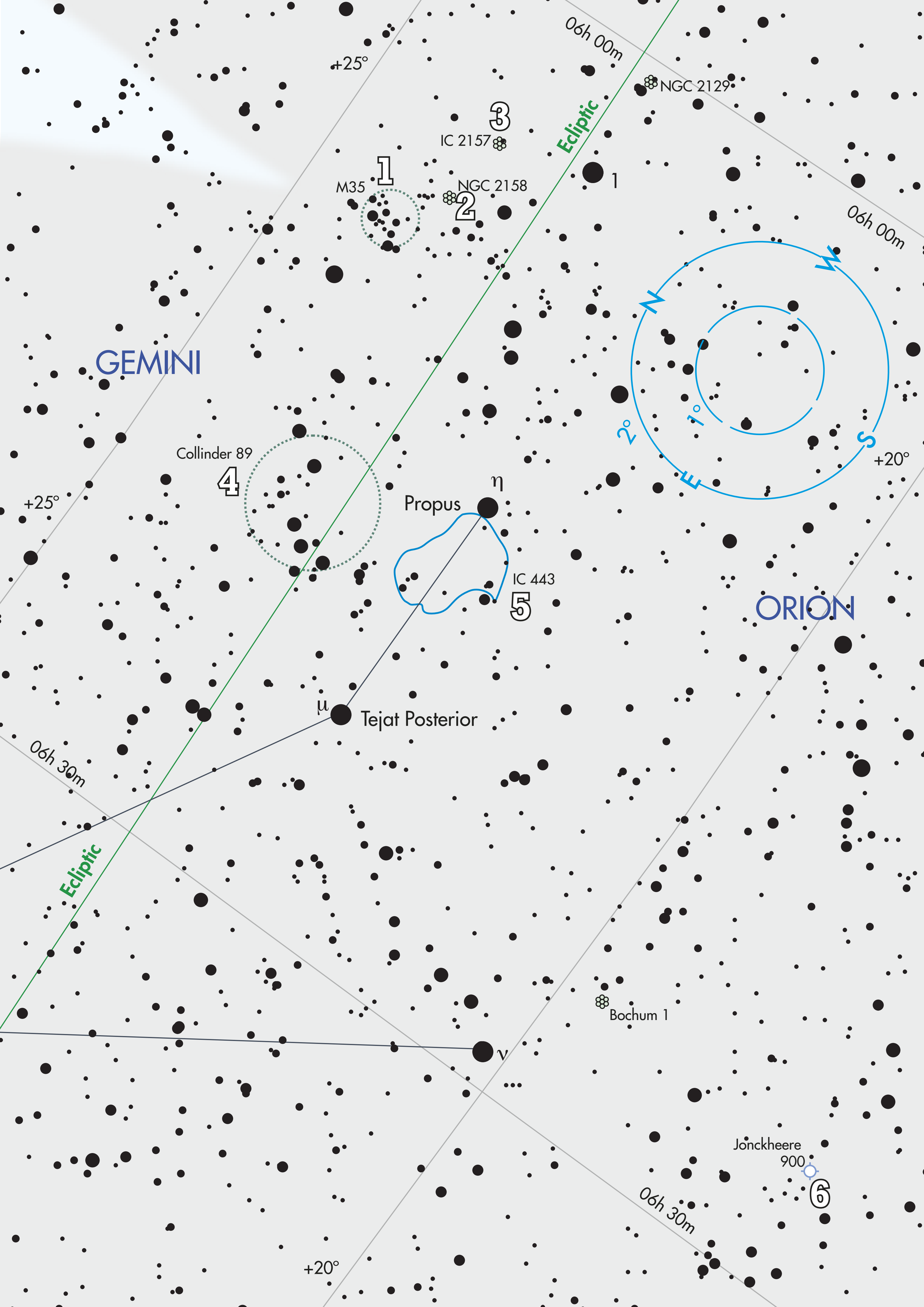
5 THE JELLYFISH NEBULA

Once you've recovered from trying to locate the elusive Collinder 89, return to the line between Propus and Tejat Posterior. The first half of the line, starting at Propus, marks the location of supernova remnant IC 443, the Jellyfish Nebula, a firm astrophotography favourite. Visually this object is a challenge and the use of an OIII filter is highly recommended. A southern 'crescent' can just about be seen visually with a 10-inch scope. IC 443 is believed to be the result of a supernova that occurred sometime between 3,000 and 30,000 years ago. The explosion shockwave is interacting with a molecular cloud present in the region. ☐ **SEEN IT**

6 JONCKHEERE 900

Our final object is planetary nebula Jonckheere 900. It sits approximately 5.5° south-southeast of the Jellyfish Nebula, but it is easier to find by drawing a line between mag. +5.2 71 Orionis and mag. +1.9 Alhena (Gamma (γ) Geminorum). Note that neither of these stars appears on this month's chart. Jonckheere 900 lies at the mid-point of this line and does a good job of hiding itself at low magnification. At 200x through a 10-inch scope, the nebula is easily mistaken for a star. Up the power further and its small, 10-arcsecond disc becomes obvious. It has a high surface brightness, which is why it's good at mimicking a star. A 12-inch scope should show that the nebula is slightly elongated. Its faint, 18th-magnitude central star is too faint for amateur scopes. ☐ **SEEN IT**

CHART: PETE LAWRENCE; PHOTO: ISTOCK



06h 00m
+25°
NGC 2129
3
IC 2157
Ecliptic
1
M35
NGC 2158
2
1
06h 00m
N
W
1°
2°
S
E
+20°
GEMINI
Collinder 89
4
+25°
η
Propus
IC 443
5
ORION
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Tejat Posterior
06h 30m
Ecliptic
Bochum 1
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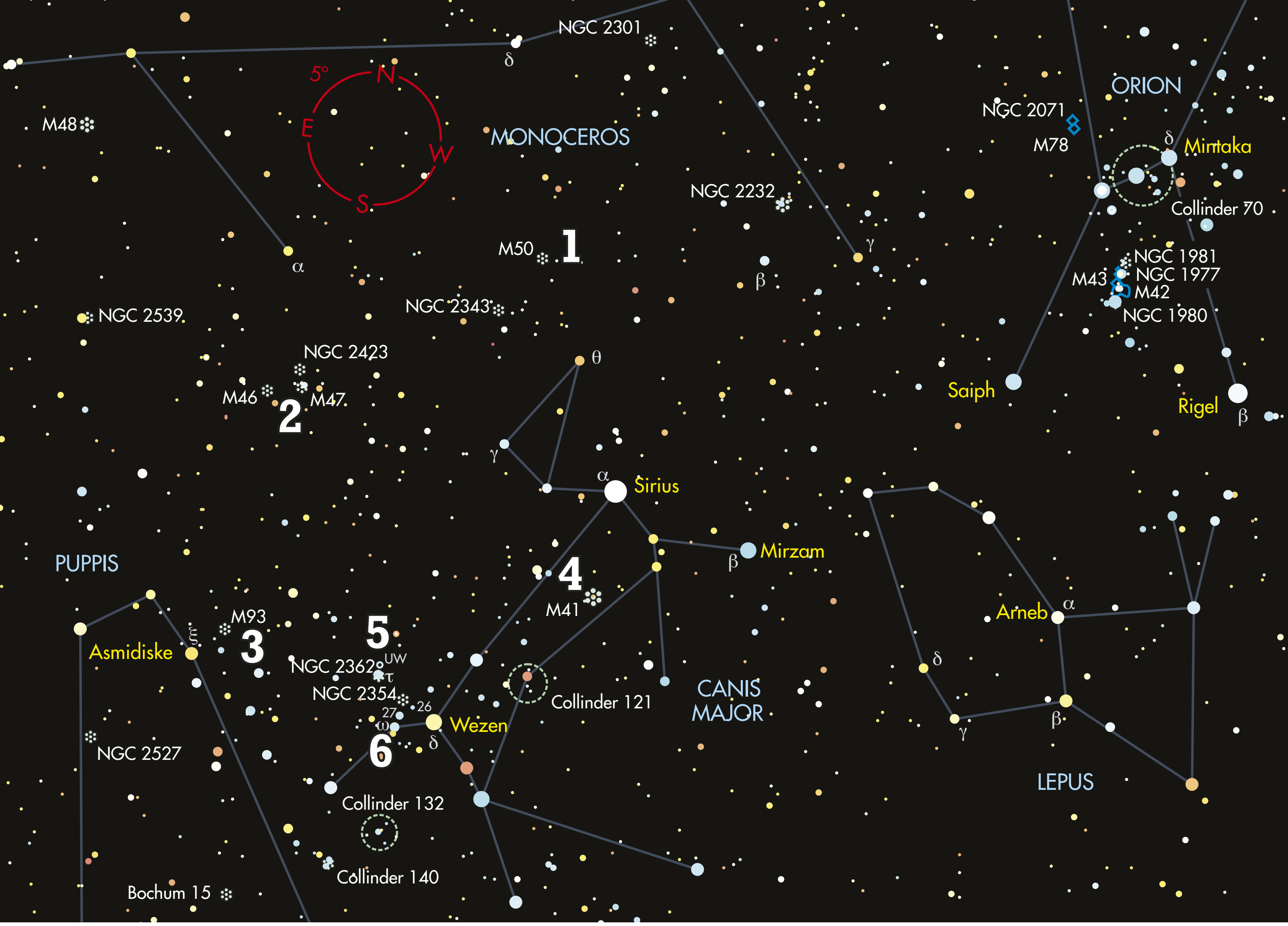
900
6
06h 30m
+20°



Binocular tour

Explore a dog's tail in Canis Major and a cluster even Aristotle was aware of

With Stephen Tonkin

☑ Tick the box when you've seen each one

1 M50

10x50 M50 is an open cluster that lies 3,200 lightyears away and spans approximately 20 lightyears. The glow comes from just over 100 stars, of which you should expect to resolve only four or five in 10×50 binoculars. Find M50 by first locating mag. –1.5 Sirius (Alpha (α) Canis Majoris). From here, navigate just over 5° north-northeast to mag. +4.0 Theta (θ) Canis Majoris, then continue another 4° in the same direction. Here you will find an obvious circular glow measuring about half the apparent diameter of the Moon: this is M50. ☐ **SEEN IT**

2 M46 AND M47

10x50 These clusters lie in the same field of view as each other, 5° to the south of mag. +3.9 Alpha (α) Monocerotis. They offer contrasting examples of how open clusters can appear in small binoculars: M47, 1,600 lightyears away, is large and loose: you should easily be able to resolve over half a dozen stars. M46 is over three times as distant at 5,500 lightyears, but is a similar apparent size. It is far more compact: although it contains many more stars than its neighbour, you may not be able to resolve any of them at all. ☐ **SEEN IT**

3 M93

15x70 If you place mag. +3.3 Xi (ξ) Puppis in the southeast of the field of a pair of 15x70s, the wedge-shaped M93 should appear approximately in the centre. This is a bright (mag. +6.2), rich and densely packed cluster in which 25-30 stars are visible in 15x70s, with more unresolvable stars giving a glowing backdrop. M93 is unusual in that the centre of the cluster, which is bounded by an arrowhead grouping of brighter stars, is relatively sparse; most open clusters are sparser at the periphery. ☐ **SEEN IT**

4 M41

10x50 M41 is 4° southeast of Sirius. This bright cluster is visible to the naked eye in a transparent sky, and was even noted by Aristotle in the 4th Century BC. It appears slightly larger than the previous four clusters and, in 10×50s from a reasonably dark sky site, you should be able to resolve up to 10 brighter stars against the background glow of fainter stars – you may need to use averted vision. If the sky is transparent enough, see that the stars differ in colour, with the brightest one, near the centre, being somewhat orange. ☐ **SEEN IT**

5 UW CANIS MAJORIS

15x70 UW Canis Majoris is a Beta Lyrae type variable, the distance of which is disputed. Find mag. +1.8 Wezen (Delta (δ) Canis Majoris), then look 2.7° northeast to find mag. +4.4 Tau (τ) Canis Majoris. UW Canis Majoris lies less than 0.5° north of Tau and is about 200,000 times more luminous than the Sun. It shines, usually at mag. +4.8, with a brilliant blue-white light, but every 4.39 days its brightness falls by half a magnitude as it is eclipsed by a fainter and smaller companion. ☐ **SEEN IT**

6 THE OMEGA CANIS MAJORIS GROUP

10x50 Mag. +4.0 Omega (ω) Canis Majoris lies 1.5° east of Wezen. The first thing to note about it is that it is a brilliant white compared to the fainter (mag. +5.6) yellowish star that is just to the south of it. The two are part of a pretty C-shaped string of stars of varying colours, sometimes referred to as 'the dog's tail', which extends from mag. +5.9 26 Canis Majoris in the north, through 27 and Omega Canis Majoris, to a mag. +5.4 yellow star that is just over 1° south of Wezen. ☐ **SEEN IT**

CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Crater Fontenelle

THE 38KM-WIDE crater Fontenelle sits on the northern shore of Mare Frigoris, the Sea of Cold. The most familiar feature nearby is the dark-floored crater Plato (100km), which sits in the rough terrain that separates Frigoris from the massive Imbrium Basin to the south. Look north and slightly west of Plato, across the Sea of Cold, and you'll arrive at Fontenelle.

The crater is circular with a flat floor, and a small and low mountain complex at its centre. The rim of the crater rises about 1.5km above the floor, and the southwest edge is interrupted by a line of three tiny craterlets that head southwest, ending close to a bright feature that juts into the mare.

Being relatively close to the lunar limb, Fontenelle's appearance changes with the prevailing libration. When libration is favourable it may be possible to detect rilles, or cracks, in the crater's floor, although you'll need high-magnification and a steady atmosphere to see them visually. A small mountainous region can be seen outside the rim to the northwest.

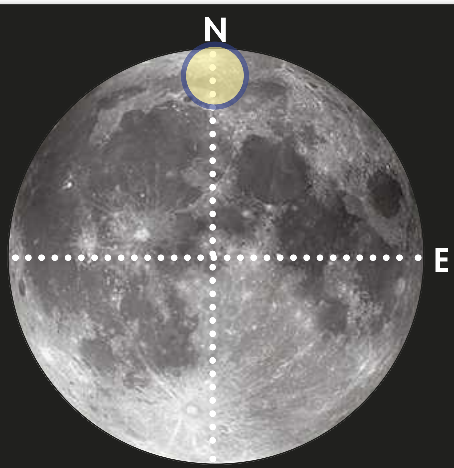
Approximately 60km west of Fontenelle lies Fontenelle D (17km). This crater forms a pair with the slightly smaller Fontenelle B (14km), which sits immediately south. Fontenelle D is a tricky concentric crater – a feature that shows one rim concentrically positioned within another. In this case the second rim is not obvious at first and requires oblique lighting to see convincingly. The inner crater is extremely shallow and has half the diameter of Fontenelle D.

The region immediately to the north of Fontenelle includes a large expanse of flat lava. The boundaries of this region are quite high and at times when the Sun is low in the lunar sky it will cast dramatic shadows across the lava below. To the east of this region is Fontenelle A (21km). A line drawn from Fontenelle through Fontenelle A will eventually reach the crater Anaxagoras (51km).

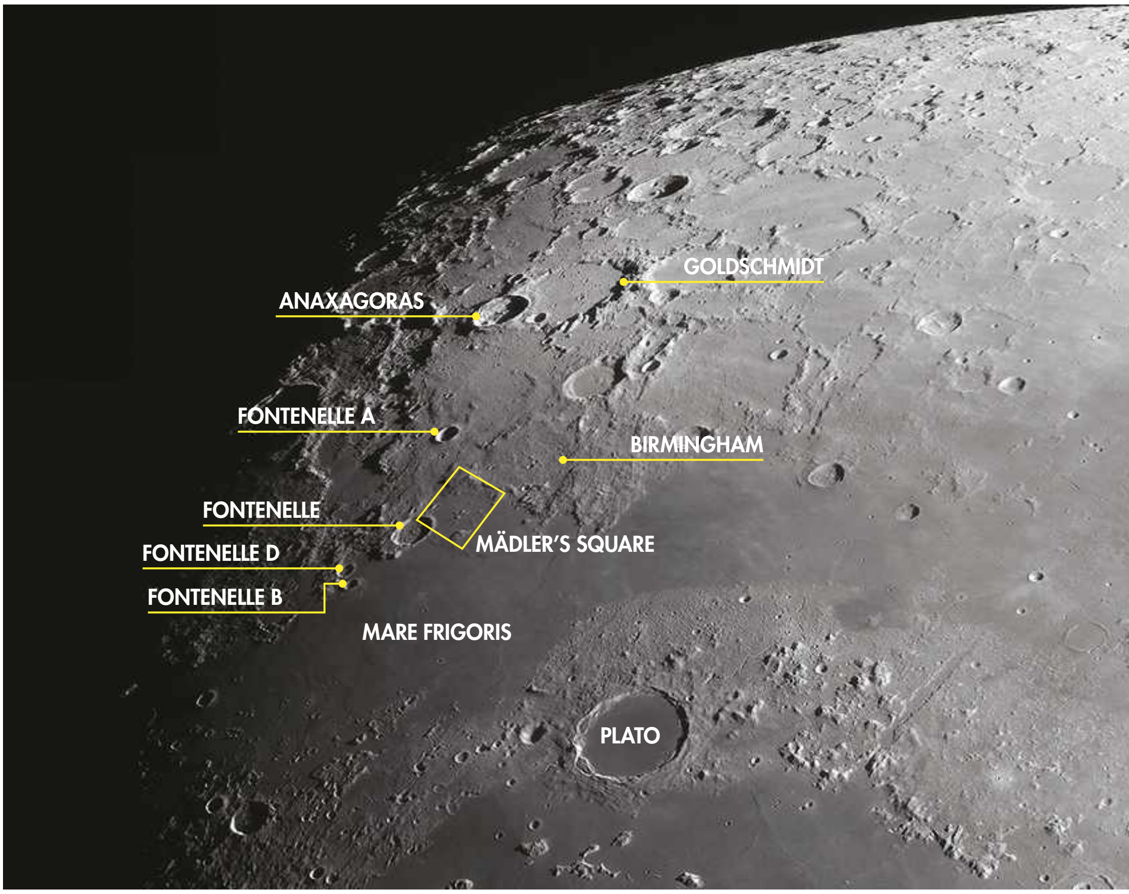
A wrinkle ridge passing southeast-northwest across the floor of Frigoris comes to an abrupt end at the southeast wall of Fontenelle. Above this is a curious area of flat lava with several elevated mountains, hills and curved formations. The northwest and northeast boundaries of this region have an approximate linearity and it's likely that they form two sides of an unofficial lunar feature known as Mädler's Square. The largest elevated structure southeast of Fontenelle, formerly known as Fontenelle Epsilon, rises 0.6km above the surrounding lava floor and marks the square's southern corner. Heavily eroded crater Birmingham (93km) sits east of Fontenelle, its southwestern rim forming the final side of the square.

STATISTICS

TYPE: Crater
SIZE: 38km
AGE: 3.8 – 3.9 billion years
LOCATION: Latitude 63.4°N, longitude 19.0°W
BEST TIME TO OBSERVE: 1 day after last quarter or 2 days after first quarter (12-13 February & 27-28 February)
MINIMUM EQUIPMENT: 50mm telescope



"When libration is favourable it may be possible to spot rilles in the crater floor"



Fontenelle lies on the edge of the Mare Frigoris, a sea sometimes described as the Man in the Moon's 'eyebrows'

Astrophotography

Mars and Venus in conjunction

RECOMMENDED EQUIPMENT

DSLR Camera, 100mm or longer lens, remote shutter release, fixed tripod or driven equatorial mount.

A well-chosen foreground object can add depth to otherwise sparse conjunction photographs

THE INNER PLANETS Mercury, Venus and Mars are relatively fast movers against the fixed backdrop of the night sky. Unlike the more distant members of the Solar System, these rocky worlds tend to have more frequent encounters with other objects. When two objects appear close together in the sky, this is known as a conjunction. This month we have a meeting between Venus, Mars and – for two nights – a crescent Moon, providing a perfect opportunity to photograph something rather special.

Watching two or more bodies apparently come together in the night sky can be mesmerising. Venus and Mars will be best seen low in the west-southwest from 19-23 February, and they are a distinctively mismatched pairing: Venus is around mag. –4.0 at the time of closest approach, while Mars is a far more modest mag. +1.3. This means that Venus will be 132 times brighter than Mars.

Photographing the pair against a darkening twilight sky will produce a shot with two star-like dots. This can be done quite simply, using a camera and a lens with a focal length of at least 100mm attached to a fixed tripod. Use a remote shutter release to take shots without wobbling the camera, a mid-to high-ISO and a relatively short exposure.

It pays to be creative with your composition. Placing a foreground object in the view can help to make the final result more interesting to the viewer. This doesn't need to be complicated, and something like a tree silhouetted against a not-quite-dark twilight sky can look amazing. Similarly, if you're located in a town or city, a shot with everything lit and carrying on as usual below the celestial meeting above can add dynamism. The trick is to avoid having something too bright in the foreground that will simply overexpose the shot.

Another option is to stop down the camera lens. Internally, this is performed by aperture blades reducing the size of the hole that lets light through to the sensor. The construction of the blades means that typically, the hole isn't perfectly circular but rather made up of very short straight edges designed to emulate a perfect circle. Through a stopped down lens, a longer exposure on a bright light source such as Venus can show a very pleasing and attractive starburst diffraction pattern.

Here, stopping down the lens will reduce the amount of light that enters the camera. Consequently, to get a decent result the exposure time has to be increased. This is where a driven equatorial mount comes in handy, because a fixed tripod will result in trailing.

If a fixed tripod mount is all that's available to you, another interesting technique is to stop down the camera and set it at a low sensitivity. Using a lockable remote shutter to take a long exposure of the planets setting will render them as trails heading towards the horizon. If you simply want a static dots-in-the-sky type shot, our natural photo enhancer – the Moon – will be on hand to help out. On 20 and 21 February, the lovely sight of a thin waxing lunar crescent showing earthshine will provide a superb addition to the scene.

KEY TECHNIQUE

CONSIDERED COMPOSITION

Without careful planning, conjunction images can simply look like two dots rather lost against the background sky. Carefully planning interesting ways to cover events like this can result in images elevated from a simple record into a composition with added appeal.

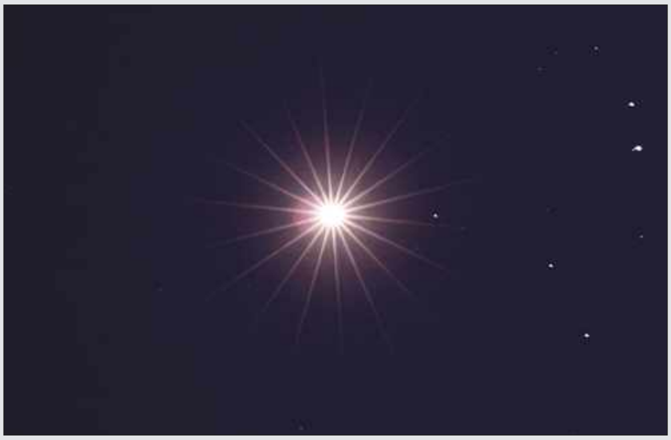
Send your image to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

STEP-BY-STEP GUIDE

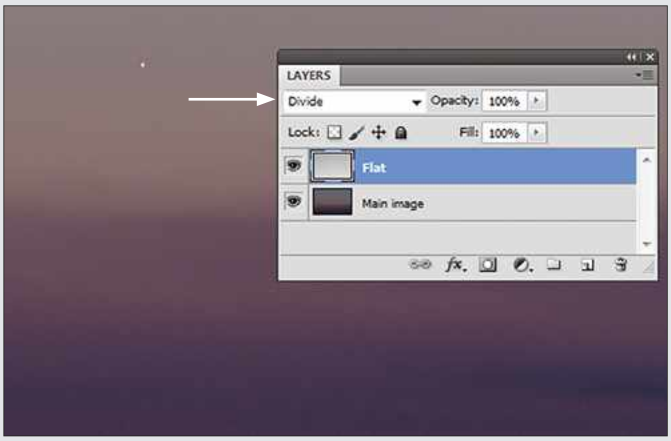
STEP 1 You don't need expensive kit to take pictures of a conjunction: a DSLR on a fixed tripod and a remote shutter release will get you started. Some point and shoot cameras may work on the Moon and bright Venus, as will some camera phones. For more sophisticated shots involving longer exposures, you'll need a tracking mount.

STEP 2 Set the camera and lens to manual. Focus the lens on Venus or the Moon, and set camera sensitivity to medium-high (ISO 400-800) and lens aperture to a low f-stop value. Close the aperture by a stop or two if the image looks distorted. Take a four-second shot. If overexposed, reduce exposure or ISO. If underexposed, increase exposure or ISO.



STEP 3 If you have a tracking mount, close the lens aperture to f/8-f/22. Set the ISO relatively high (800-1600) and take an extended shot of Venus. The result should be a bright planet at the centre of a starburst effect. This also works well with the Moon. Experiment with exposure, starting with a 10-second shot and adjusting settings as in Step 2.

STEP 4 If you find artefacts such as dust spoiling your twilight shots, take flat frames. Using the same f/number and focus settings, point the camera at an evenly lit patch of clear sky and take an image. Its histogram peak should be around the 75 per cent mark. Moving the camera while taking the shot will reduce the probability of imaging stars as bright points.

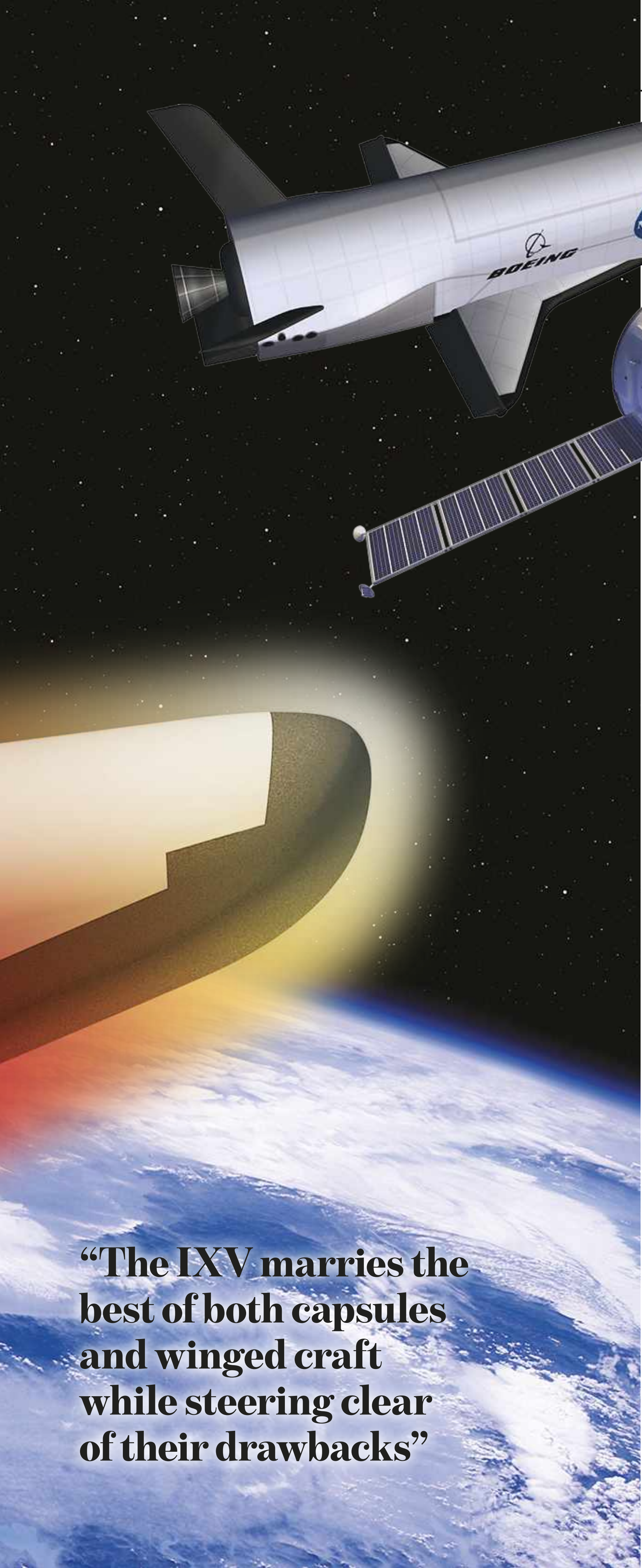


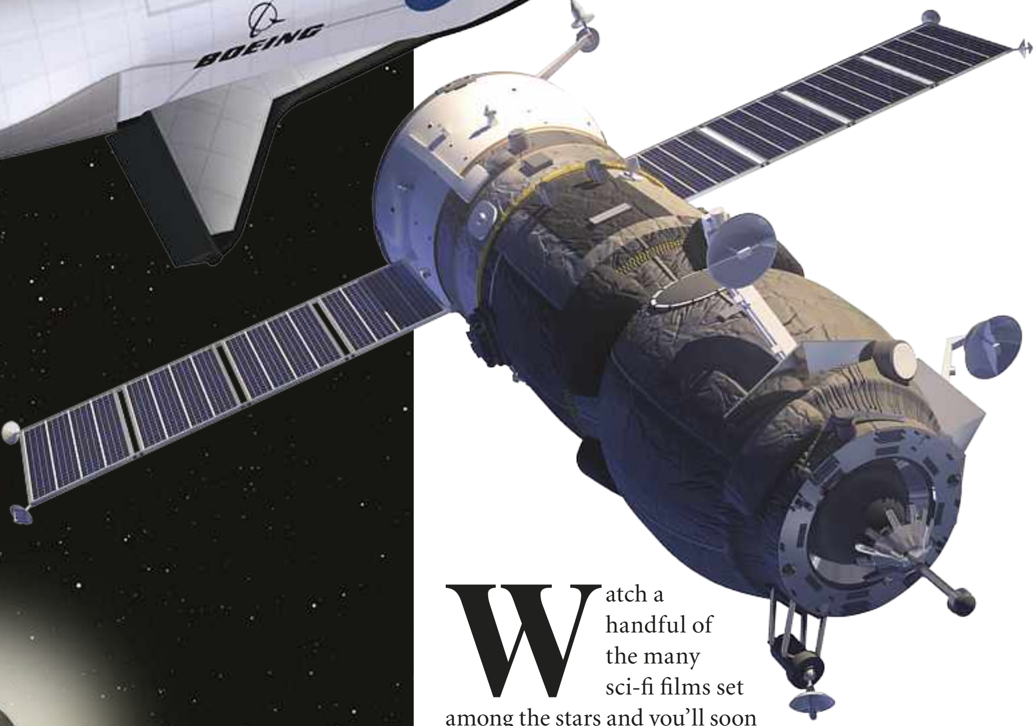
STEP 5 DeepSkyStacker can be used to apply the flat frames to the main shots. Alternatively, using a program such as Photoshop, load the main image with the flat field in a separate layer above it. Set the blend mode of the flat image to 'Divide' to remove the unwanted image field artefacts. Converting the flat image to black and white can reduce colour shift issues.

STEP 6 If using a basic untracked setup, placing a foreground object in front of the conjunction can help to give it some context. Conjunction shots taken in an urban environment can look amazing, emphasising the contrast between the human world merrily going about its daily business while the celestial show takes place in the sky above.

TRIAL BY FIRE

Will Gater looks at the experimental spacecraft blazing Europe's trail to the stars and back





◂ **Wings and capsules represent the opposing ends of current spacecraft design: left is the US's X-37B, below is Russia's Soyuz**

"The IXV marries the best of both capsules and winged craft while steering clear of their drawbacks"

Watch a handful of the many sci-fi films set among the stars and you'll soon notice that there is an incredible diversity of spacecraft exploring our Galaxy and beyond. But if you wanted to travel into space and re-enter Earth's atmosphere safely right now, you've only got a few design options. In fact, says the European Space Agency's Giorgio Tumino, you can categorise them all into three distinct classes.

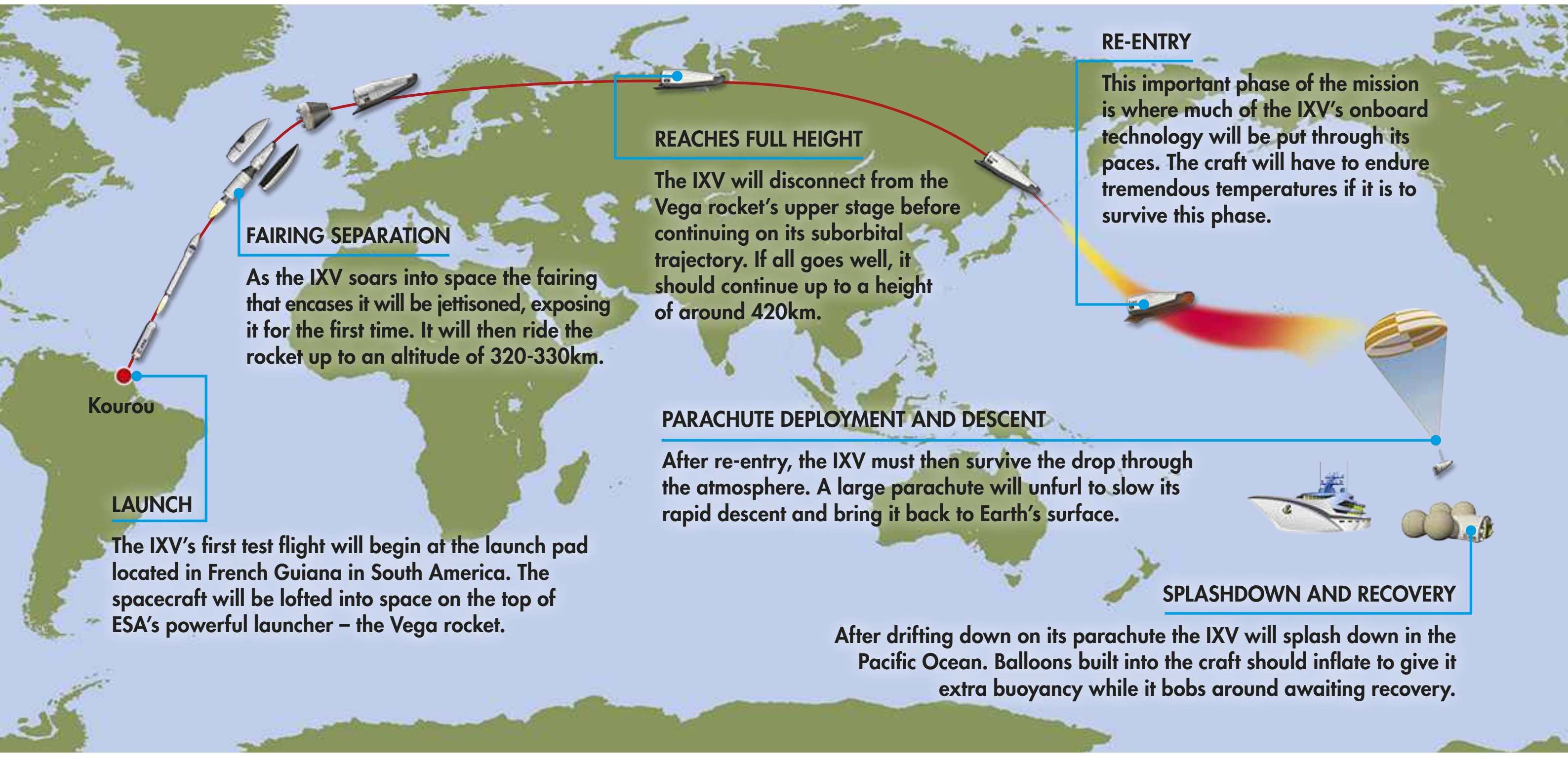
First are the capsules. These have been the mainstay of numerous space missions for decades, from the early US Mercury programme right up to the present-day Russian Soyuz craft used to take astronauts and cosmonauts to and from the International Space Station. While their design is relatively simple, capsules are not particularly manoeuvrable. "When you re-enter with a capsule you have to start from the right place if you want to end up in the place you intend," says Tumino.

At the opposite end of the spectrum is the design Tumino calls the 'winged body'. These include the now retired Space Shuttle and the US military's enigmatic X-37B space plane. "Here you have very complex systems but you get a highly manoeuvrable and controllable craft, so you can really tackle precision landing because you have wings and rudders and so on," he says.

The downside is that this design brings with it high costs and high risk. "You need the wings for the last five minutes of the flight to bring you down to a runway," he explains. "But you have to bring all this hardware, all this complexity, all these structures that can fail during the flight with you, just for these last five minutes."

The third spacecraft design is different. It's what's known as a 'lifting body'. "A lifting body means ▸

ANATOMY OF A **TEST FLIGHT**



▸ that the shape of the spacecraft on its own has the capability to provide lift, and fly like a plane," says Tumino.

For the last decade or so, Tumino and his colleagues across Europe have been designing and developing a new lifting body test spacecraft called the Intermediate eXperimental Vehicle (IXV). The IXV's design marries the best elements of both capsules and winged craft while steering clear of their drawbacks, explains Tumino, who is the programme manager for the project. "It means that we have the capability to manoeuvre and control our system in such a way that we get to a precision landing point without the need for wings."

Start at the bottom

Years of work by the ESA team have produced an unusually shaped spacecraft – somewhat reminiscent of a 5m black and white rock-climbing shoe – that today is being made ready for its maiden test flight into space. Rather than having one specific celestial destination in mind for the IXV, ESA's plan is to first use it to test the advanced technology and components needed to make a safe re-entry into Earth's atmosphere. It's a bottom-up approach to space exploration.

> "The IXV will have a suborbital trajectory – a long distance 'lob' across the globe"

"ESA's idea was to create, consolidate and grow the technological foundations of these atmospheric re-entry capabilities to build on them," Tumino explains.

One of the crucial pieces of technology being tested on this first flight is the IXV's thermal protection system. This comprises the heat shield as well as the special protective coatings on the rest of the craft, all of which are needed if it is to survive the heat of re-entry. "We have the most advanced thermal protection systems ever built in Europe," he adds.

The heat shield itself is made up of a number of large, black panels made of a material known as a ceramic matrix composite. "These have carbon fibres embedded into ceramic/silicon carbide matrixes. So they have the strength of the carbon fibre and the resistance to the heat of the silicon carbide," says Tumino. "It's a very high performing material."

On the surface the heat shield looks very similar to that found on the US Space Shuttle. However there's an important difference: "On the Shuttle you had small tiles that sometimes flew off. These pieces are really bolted on panels." In addition to the main heat shield, the rest of the IXV is protected by a white 'ablative'

▼ The IXV's heat shield is the most advanced ever built in Europe

ESA/J. HUART/2014 X 2, ESA, ISTOCK

coating. Together these two materials should protect the sensitive electronics and instruments inside the spacecraft from outside re-entry temperatures of around 1,700°C.

Sending the IXV into space and getting it to re-enter our atmosphere is the only way to fully examine if it can withstand this environment.

"In-flight testing is something very important for re-entry because on the ground you're not able to reproduce the actual flight conditions," he says. "You can do a lot of work on the ground to develop the technology, the manufacturing processes, the way the material resists the heat and so on. But at the end you never get the combination of all the elements that you will face during flight, like the right temperature at the right pressure at the right moment of the flight."

The IXV's test flight will begin at the spaceport in Kourou, French Guiana. Here the spacecraft will be mounted on top of one of ESA's Vega rockets, which will launch it out over the Atlantic Ocean and into space.

Sub-orbital manoeuvres

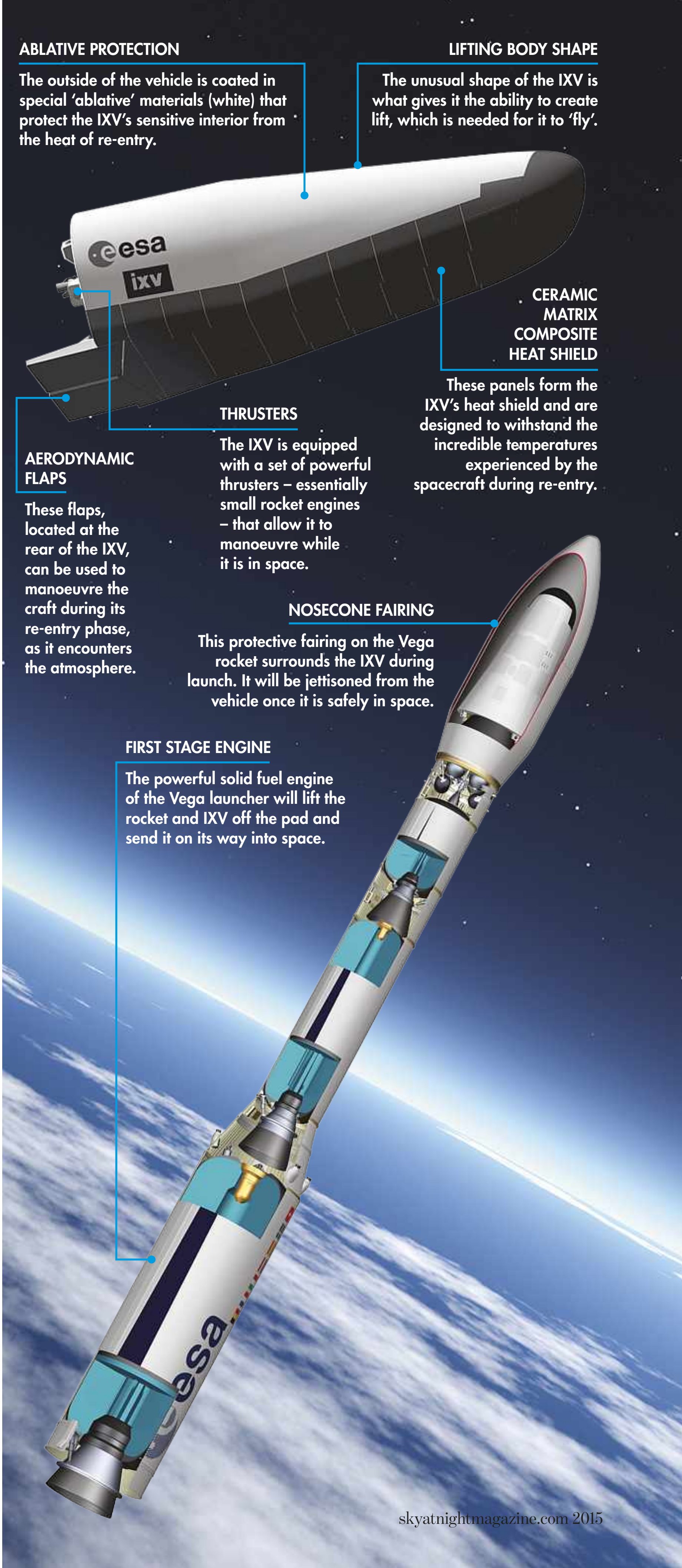
Unlike most of the satellites and spacecraft that launch from Kourou, the IXV won't be going into orbit. "To have fully representative conditions of a return from orbit you don't need to go to orbit," explains Tumino. "You just need to hit the atmosphere at a height of 120km under the same conditions as if you had come down from orbit – the speed, the flight path angle and so on."

To meet these requirements the IXV only has to follow a suborbital trajectory – essentially a long distance 'lob' across the globe (briefly going into space) rather than completing a full circuit of the planet. The entire flight is expected to last around 100 minutes. Throughout, teams on the ground will be gathering and scrutinising test data sent back by a multitude of sensors on the craft.

"We have more than 300 sensors, including infrared cameras, pressure gauges, strain gauges, pressure ports and displacement sensors," says Tumino. All this onboard instrumentation hints at why the IXV won't be deploying anything – like a satellite – during this first trip into space: as Tumino notes, it is the subject of the experiments.

"As it is experimental hardware, the vehicle itself is the payload," he says. "We do not have a payload bay in the sense that we do not have one single payload. In fact the whole mission is integrating hundreds of payloads – the sensors."

The Vega rocket will take the IXV up to an altitude of 320-330km. At that point the two will part ways and the IXV will continue on up to a height of 420km. While in space, the IXV will be able to make small pointing manoeuvres using a set of built-in rocket thrusters – the same as those used by ESA's Ariane 5 rocket. Its sub-orbital trajectory will take it east towards the Pacific Ocean, but there will be no one on Earth piloting it during the flight. ▸



▲ **The ocean recovery plan has already been practised using a prototype**

► "It's completely autonomous, but we will be following it from the ground using the flight data it will be sending us," says Tumino.

The moment of truth for the IXV will be the re-entry. Here it will not only have to withstand scorching temperatures, but also navigate along a very specific route, known as a 're-entry corridor'. It'll be up to the onboard computers to get the IXV through.

"Basically it has a pre-programmed landing spot in its brain," explains Tumino. As it interacts with the atmosphere during re-entry the IXV's instruments will constantly monitor its position to keep it on course. Any steering adjustments needed during this period will be made by the onboard thrusters and two aerodynamic 'flaps' mounted at the tail end of the vehicle. "If they move together they adapt the pitch angle," says Tumino. "If they move in a differential way then they will create yaw and roll so the vehicle can steer. It has to steer. It won't come down in a straight line because it is necessary to steer and to have banking manoeuvres to be able to survive re-entry."

Once safely through the atmosphere the IXV will open a parachute before splashing down in the Pacific (see 'Anatomy of a flight test', page 64). During the last part of the flight, a special recovery ship will be on hand to track its descent and eventually pluck the IXV out of the water.

▲ **An IXV successor has already been mooted: PRIDE would trial a runway landing**

Although the project doesn't have a Kennedy-esque goal to aim for, there is no shortage of future uses for the technology it's testing.

"Without being able to re-enter the atmosphere it is hard, if not impossible, to plan sample-return missions," says Tumino. "If you need to bring back samples from other planets, asteroids or comets, you need to return in one piece.

"It's the same for human spaceflight – if one day Europe ever has the ambition to have European systems to bring astronauts back, this is a necessary step."

It's even hoped that future tests may include landings on the ground or a runway. Perhaps, then, it's the IXV, not the silver screen, which presents a truer vision of the future of spacecraft design. Ⓢ

NERI - LIVORNO (I), ESA/J. HUART/2012

ABOUT THE WRITER

Will Gater is an astronomer, science writer and author of several popular astronomy books, including *The Practical Astronomer*. He tweets as @willgater.

It's crucial to think about composition: the aurora often works well as a backdrop, not the subject of a photo

NORTHERN ENLIGHTENMENT

Jamie Carter journeys to Finnish Lapland to find out exactly what makes a good aurora photo

Even a vague green glow is enough; a DSLR camera is much more sensitive than the human eye

WHAT TO TAKE

You'll ideally want a DSLR camera, but many bridge cameras are also capable of capturing good images. A tripod is essential. A remote shutter cable is also useful, though most cameras have a two-second shutter delay option. Also take a spare battery, extra memory cards, a red-light headtorch and binoculars for stargazing. If you have the budget for it, a wide-angle lens is a bonus.

Hunting for aurorae means being outside from about 9pm until 1am, and in Finland the temperatures regularly sink to –30°C. Most tour operators will provide you with a snug Arctic 'onesie', fur-lined boots and over-mittens, but be sure to bring the basics: thermal leggings or padded trousers, a base layer and thin socks (merino wool is unbeatable for both), thick woollen socks, a fleece, a scarf or neck warmer, gloves that enable you to operate the camera (not fingerless) and a hat that covers your ears.

Don't forget to grab a shot like this one for social media

It was time to head north. After hearing tales of frequent, powerful displays in Finnish Lapland, I knew this was the year to see the aurora borealis – and my DSLR camera was coming with me.

In theory, it's never been easier to photograph this natural light show. We're now in the early declining phase of a solar maximum, when the green glow or – if you're lucky – rippling curtains topped with red are historically at their most frequent and spectacular.

Barely an hour after arriving at our hotel on the shore of frozen-over Jerisjärvi Lake in northwest Finland, 20km from the nearest village, we were standing in a forest clearing while the aurora borealis twisted, shimmered and pulsed above us. There were six of us, all hoping to photograph one of nature's most elusive sights, and we were not disappointed; there were just as many chuckles of relief as there were clicks of camera shutters.

Our first workshop in aurora photography wasn't due to take place until the next morning, so our trip to the forest clearing started with an impromptu lesson in the basics from our guide: put your DSLR camera on a tripod in manual mode, whack up the ISO to between 800 and 1600, set the aperture to f/3.5 or as near as possible and open the shutter for about eight to 20 seconds… then experiment. The unpredictable brightness and intensity of auroral displays is the deciding factor in what settings will work best.

Perparing for the lights

Having previously spent time at dark-sky sites trying to image constellations, star trails and night-time landscapes, I was reasonably well prepared for fiddling with a tripod and camera in the dark. However, the hands-on help of an expert proved invaluable for this first attempt.

That first night was astounding. A faint green glow to the north gradually spread south until it appeared high above us, twisting and pulsing, and picking up power. Unfortunately the first phase of this superlative display passed without me having taken a decent image because my lens kept slipping out of focus. Thankfully the lens was swiftly put back into the ▸

Foreground objects can add interest; this particular tree looks as if it's on fire

Strong displays cover a large area of sky, so a wide-angle lens is crucial

▸ correct position and fixed there by our tutor, Gareth Hutton; not only was having a professional in tow useful for the advice, the masking tape in his pockets was a godsend.

I was better prepared for the second burst of auroral activity and managed to snap some nice landscape shots; even a few arty shots of a birch tree seemingly ablaze with green swirls appearing to stream down its branches. After seeing red-tinged auroral curtains and rapidly moving green swirls, a thin wavy line suddenly shot above us, which I also managed to capture. It was one of the most exciting hours of my life, right up there with a total solar eclipse.

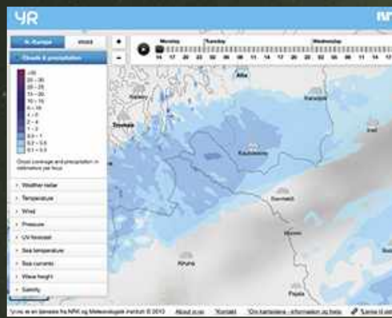
During a lull in activity, we drove up to Pallas-Yllästunturi National Park to instantly see a faint, much slower moving aurora hanging over a high snowy fell. The

TRACKING DOWN THE NORTHERN LIGHTS

▶ Get to 64°-70° latitude from the end of August to the end of March. The equinoxes are particularly good. Avoid any week that the Moon is full if you want to take other astro images.

▶ Bookmark http://solarham.net, a reliable three-day geomagnetic forecast used by aurora hunters.

▶ Also bookmark www.yr.no: this site offers the best weather map for finding gaps in Lapland's frequently thick cloud cover.



▶ Having an experienced aurora photographer as a guide and driver will give you a massive advantage.

▶ Set your camera on the correct settings and attach it to its tripod before you head outside.

▶ Use a compass to find a location with a good view of the northern sky.

▶ Faint wisps of grey on the northern horizon will be revealed as green by your camera, and could signify the beginning of an auroral substorm.

▶ Wrap up warm and bring a flask of something hot because going to bed at 11pm, especially on a clear night, is not an option.

A NORTHERN LIGHTS TOUR LEADER

Photographer Gareth Hutton advises getting to know your camera before travelling

"Modern cameras make it much easier for people to take incredible pictures, and this is also the first solar maximum where digital cameras have been the dominant type of camera," says Gareth Hutton, a New Zealand native who got hooked on the aurora after his Finnish wife dragged him into the Arctic wilderness with a camera in tow.

Photographing the Northern Lights isn't too difficult, he says. "The biggest mistake most people make is that they don't know their cameras well enough to quickly change settings in the dark. I would advise anyone heading up here that they switch off the lights at home and spend a bit of time in darkness practising changing the shutter speed, the aperture and the ISO until it's second nature, because when the aurora comes you don't have time to hang around."

Most visitors to the Arctic Circle are happy enough to get a few photos to post on social media, but experienced photographers are pioneering new ways of capturing aurorae. "The trends are set by those living in aurora regions who have the opportunity to shoot every night," says Hutton. "Timelapse was the first logical progression, and with the increased ISO capabilities of cameras today it's only natural that real-time video will follow."

Most of the real-time videos of the Northern Lights that are starting to appear on social media streams are from local photographers and videographers using high-end DSLRs with ISOs as high as 25600. For those of us without top-end kit, there is one trend that's much more accessible: the Northern Lights selfie!

AURORA PHOTOGRAPHY **TOURS**

The Aurora Zone's seven-night Torassieppi Aurora Photography trip, on which Jamie Carter travelled, runs in January, February and March 2015. It costs £2,108 per person, including direct flights and an aurora photography workshop with Gareth Hutton.
www.theaurorazone.com

Tatra runs a six-night aurora photography trip to Iceland on 27 January and 17 February for £2,495 per person, including direct flights, accommodation in a 'travelling hotel' and expert tutoring from British landscape photographer Mark Bauer.
tatraphotographyworkshop.com

Joseph Van Os Photo Safaris runs a seven-night trip to Chena Hot Spiring Resort that takes in aurora hunting, the North American Championship Sled Dog Races and the World Ice Art Championships. The tour departs on 13 March and costs $3,995 (£2,555) per person.
photosafaris.com

Omega Holidays runs three-hour Northern Lights flights to the Arctic Circle from 18 regional UK airports in January and February for £199.95 per person. Price includes a presentation about the aurora by a guest astronomer, and the plane features rotating window seats.
www.omega-holidays.com

next evening we drove to Pallasjärvi Lake – primarily because it was in a cloud-free corridor – and eagerly awaited the aurora.

The tricks of composition

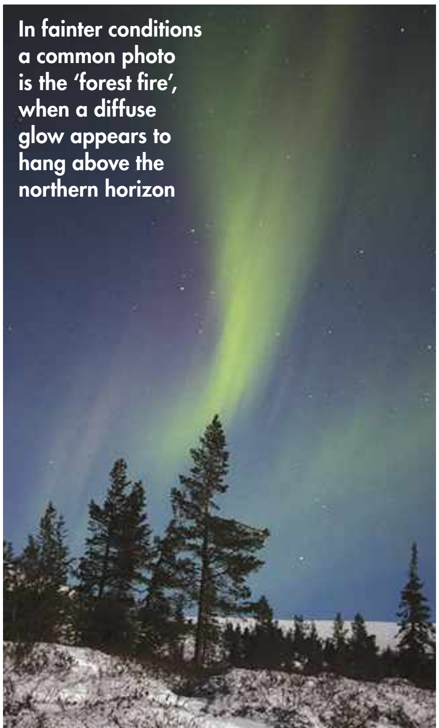
We had clear horizons to the north and east, and the glare from the gibbous Moon caused a string of rowing boats on the icy shoreline to cast long shadows. It was the perfect setting for the next and most important lesson: composition. Hutton headed straight for the boats to line up a shot, and the rest of us followed. That morning's aurora photography workshop had taught us all a truth about aurorae that is not often voiced but is essential if you're hoping to get great images: in most photographs they just look like clouds. Green they may be, but it's imperative to use them only as a backdrop to a photo, and not the sole subject.

Often a tree is sufficient, or perhaps a building or a fellow photographer, but the usual rules of photography still apply: get your subject away from the centre, apply the rule of thirds and try to include diagonal objects. It's not easy to do, but with this well-chosen site we had plenty of practice. In the event, the hour I had spent lining up the perfect shot of a boat beside the lake while waiting for the aurora produced dividends, and I eventually got the kind of aurora landscape photographs I had always dreamed of capturing.

Although the display that night wasn't as strong as the night before, for 25 minutes they streaked towards the eastern horizon across a lake and into my camera's field of view. Most of my photos featured boats, the icy lake and dramatic auroral bands, with the added bonus of a bright Jupiter rising. Lapland couldn't have been any more photogenic, nor the cosmos kinder.

ABOUT THE WRITER

Jamie Carter is a tech and travel writer with the astronomy bug. He's a veteran of aurora hunts and eclipse chases around the world.



In fainter conditions a common photo is the 'forest fire', when a diffuse glow appears to hang above the northern horizon

Auroral activity on the first night of the trip was astounding

VISUAL OBSERVING GUIDE

PART 2: VARIABLE STARS

Paul Abel's guide to visual observing continues with tops tips on how to record the waxing and waning of variable stars

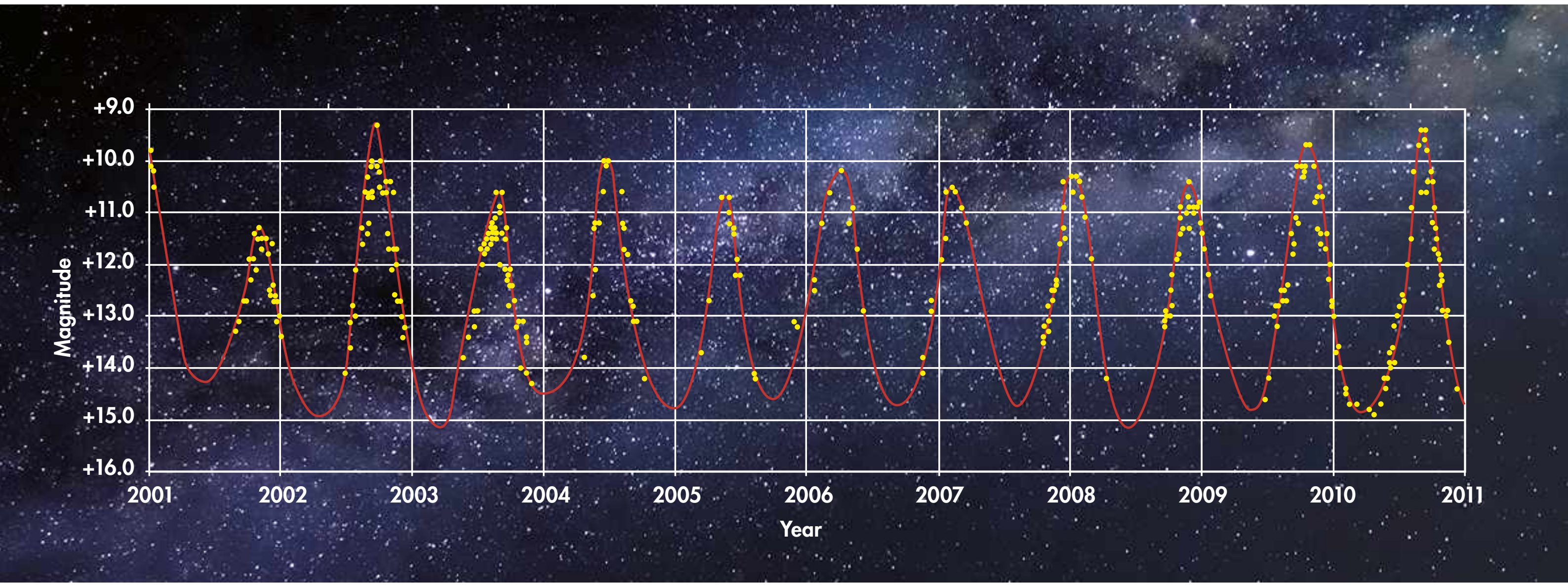
At first glance, the stars in the night sky all appear alike – cold points of light lying far away. However, after a few minutes subtle differences become clear: some are different colours, some appear fainter than others, and so on. But there is one property of some stars that can take longer to pick up: not all stars stay at the same brightness all the time.

These wonderful objects are called variable stars. Many of them 'vary' – that is, complete a cycle where they dim and then brighten again– over the course of a night, but some take over a year. Studying these stars has provided some fascinating insights into modern astrophysics and the private lives of stars.

It took a surprisingly long time for variable stars to be identified. In the modern era the first one was discovered by Johannes Holwards in 1638 when he noticed that Omicron Ceti varied over the course of 11 months. Since then, many thousands of variable stars have been identified. While the astrophysics of variable stars is of great interest to professional astronomers, most observations of these stars come from amateurs. ▸

JON HICKS

VISUAL OBSERVING GUIDE
COMING SOON
PART 3: SUPERNOVA PATROLS



▲ **Light curves can reveal patterns: this one shows the fluctuations in the brightness of cataclysmic variable star SS Cygni over a period of 10 years**

▸ The main focus of variable star observation is making estimates of magnitude. These estimates can be plotted against time to generate a light curve like the one above, which reveals the period of time in which the star varies, its brightest and faintest magnitudes, and any long-term fluctuations hidden in its constant changes. There are many different types of variable star, and organisations such as the British Astronomical Association (BAA) and the American Association of Variable Star Observers (AAVSO) run a vast number of variable star campaigns, in which stars are monitored by many amateur astronomers, and their observations are used to generate the much-needed light curves.

TYPES OF VARIABLE STAR

There are several general classifications of variable star types, many of which have their own sub-classifications.

▶ PULSATING VARIABLES are stars that vary periodically due to the expansion and contraction of their surfaces.

▶ IRREGULAR VARIABLES vary with little or no apparent period.

▶ CATACLYSMIC VARIABLES vary due to violent thermonuclear processes occurring on their surfaces (eg due to accretion discs) or deep inside their interiors (supernovae).

▶ ERUPTIVE VARIABLES produce violent flares and flashes in their outer atmospheres, which causes their magnitudes to vary.

▶ ECLIPSING BINARIES are binary stars that vary due to one component passing in front of the other and temporarily blocking some or all of its light.

LIGHT CURVE CHART BY PAUL WOOTTON, STAR MAGNITUDES CHART BY PETE LAWRENCE, ESO/L. CALCADA

Getting started

Becoming part of the movement that monitors these stars is simple and there are many variables you can make a start with. Gary Poyner of the BAA Variable Star Section has provided some good targets for beginners on the opposite page; as a rule it is best to start with a couple of stars then build up to a manageable list.

Observing variable stars doesn't require expensive kit: you can observe with a small or large telescope – there are plenty of stars to go around! It's a good idea to have a selection of eyepieces as it's easier to locate stars at low magnification, then switch to high magnification to home in on the ones close to the limiting magnitude of your telescope. A sturdy notebook to act as your log, a reliable pen and a red light are also helpful.

A correct star chart is also essential. It must show the location of the variable star in the sky, and indicate comparison stars to use for making magnitude estimates. This is important since we can't use other variable stars for making comparisons. The BAA Variable Star Section and the AAVSO are the two most reliable sources for charts – just go to their websites, find the star you want a chart for and print it out. Remember to record which chart you are using in your logbook.

Make sure you're fully dark adapted before you start observing. The hardest part is tracking down the star in question, and for this I always use a lower power eyepiece (100x or so). If your telescope has

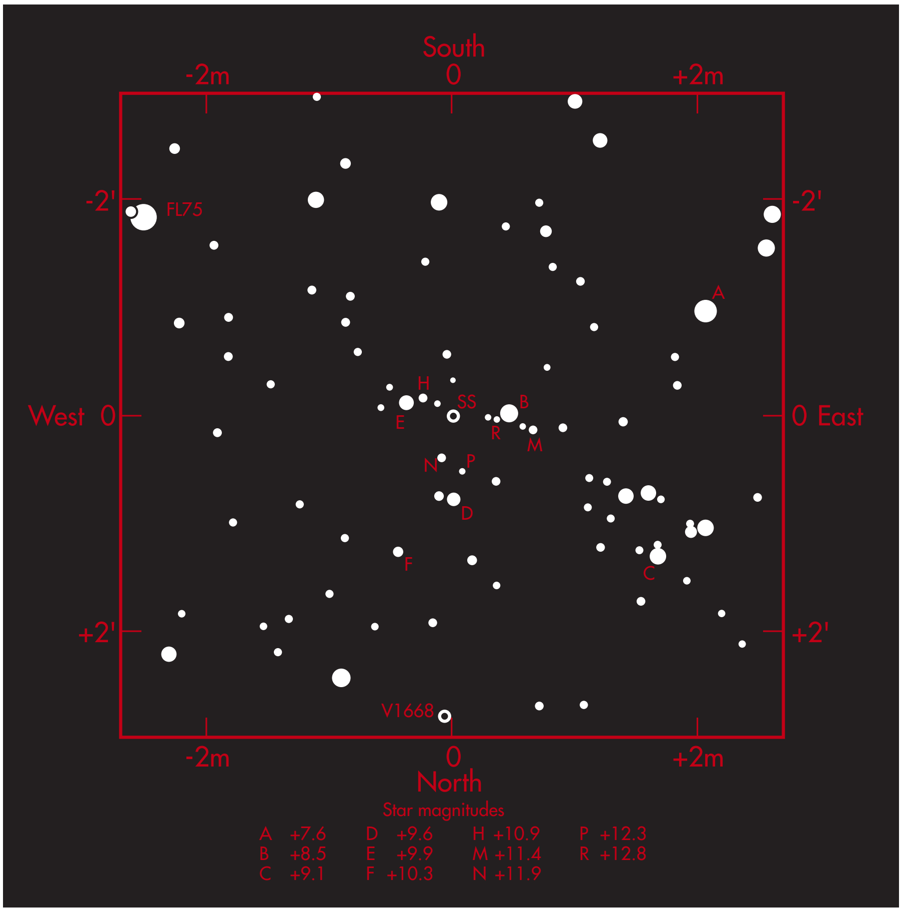
ESTIMATING STAR **MAGNITUDES**

To estimate the magnitude of a variable star you need to judge it against a comparison star of fixed brightness and evaluate the difference to one-tenth of a magnitude. It's best to use two comparison stars: one brighter than the variable and one fainter.

Suppose you were observing SS Cygni, as seen on the chart. If SS Cygni appears three-tenths fainter than Star C, you would record an estimate of 'C–3'. If it was also one-tenth brighter than Star D you would record 'D+1', giving us two estimates for this star. You now convert these two estimates into magnitudes.

On the chart Star C is given as mag. +9.1, so the estimate 'C-3' is 9.1+0.3 (since three-tenths is 0.3). This gives a magnitude of +9.4. Star D is listed as mag. +9.6, and so the estimate 'D+1' gives 9.6–0.1, which is mag. +9.5. Taking the average of the two and rounding up gives a deduced magnitude of +9.5.

If the variable is too faint to be visible, use the faintest comparison star on the chart you can see. If, for example, the comparison star is Star F, the estimate would be '<F' and the magnitude <+10.3. Record both your estimates and the deduced magnitude in your logbook.



setting circles, use them to get your scope aimed at the right location, otherwise use binoculars to track down the right area of sky. Don't be disheartened if it takes a number of attempts to find your chosen star– you'll get there in the end.

Contributing to science

The main task is to estimate the magnitude of the variable (see 'Estimating star magnitudes', above, to find out how). Record these in your logbook at the telescope along with the date, time (in UT) and telescope details. You will need to do this for each observation, and I find it best to keep a separate book for each variable star.

It's essential that you report your observations so that they can be used by the whole community. Both the BAA (**www.britastro.org/vss**) and the AAVSO (**www.aavso.org**) will be grateful for them. These organisations have knowledgable astronomers who can help you with any problems you may experience. You can upload your observations using their websites, or alternatively you can post a paper version. Both sites also allow you to generate light curves for your data so you can compare them with other observers.

Variable star observing is very rewarding. There is something special about studying the life of a star that may be hundreds of lightyears away from us on planet Earth. Your chosen star will need observing indefinitely, so a variable star is a lifelong friend. S

ABOUT THE WRITER

Dr Paul Abel is an astronomer based at the University of Leicester. You can listen to him on our Virtual Planetarium each month.

VARIABLE STAR TARGETS

STAR	RA, DEC	TYPE	RANGE	PERIOD	HOW OFTEN TO OBSERVE
WINTER VARIABLE STARS					
RX And	01h 04m, +41° 17'	Cataclysmic (UGZ)	+10.3 to +14.8	14 days	Nightly
AX Per	01h 36m, +54° 16'	Cataclysmic (ZAND)	+9.4 to +13.6	681.6 days	Nightly
RR Tau	05h 39m, +26° 22'	Eruptive (UXOR)	+10.2 to +14.3	-	Nightly
U Ori	05h 55m, +20° 10'	Mira	+4.8 to +13.0	268.3 days	Weekly
Z And	23h 33m, +48° 49'	Cataclysmic (ZAND)	+7.7 to +11.3	-	Nightly
SPRING VARIABLE STARS					
Z Cam	08h 25m, +73° 06'	Cataclysmic (UGZ)	+10.0 to +14.5	22 days	Nightly
Z Uma	11h 56m, +57° 52'	Pulsating (SRB)	+6.2 to +9.4	195.5 days	Weekly
U Boo	14h 54m, +17° 41'	Pulsating (SRB)	+9.8 to +13.0	201.3 days	Weekly
R CrB	15h 48m, +28° 09'	RCB	+5.7 to +15.2	-	Nightly
V CrB	15h 49m, +39° 41'	Mira	+6.9 to +12.6	357 days	7-10 Days

The Beginners' guide to **Astronomy**

If you're starting out in stargazing, it's a good idea to learn a little about the night sky and get a decent beginner's scope

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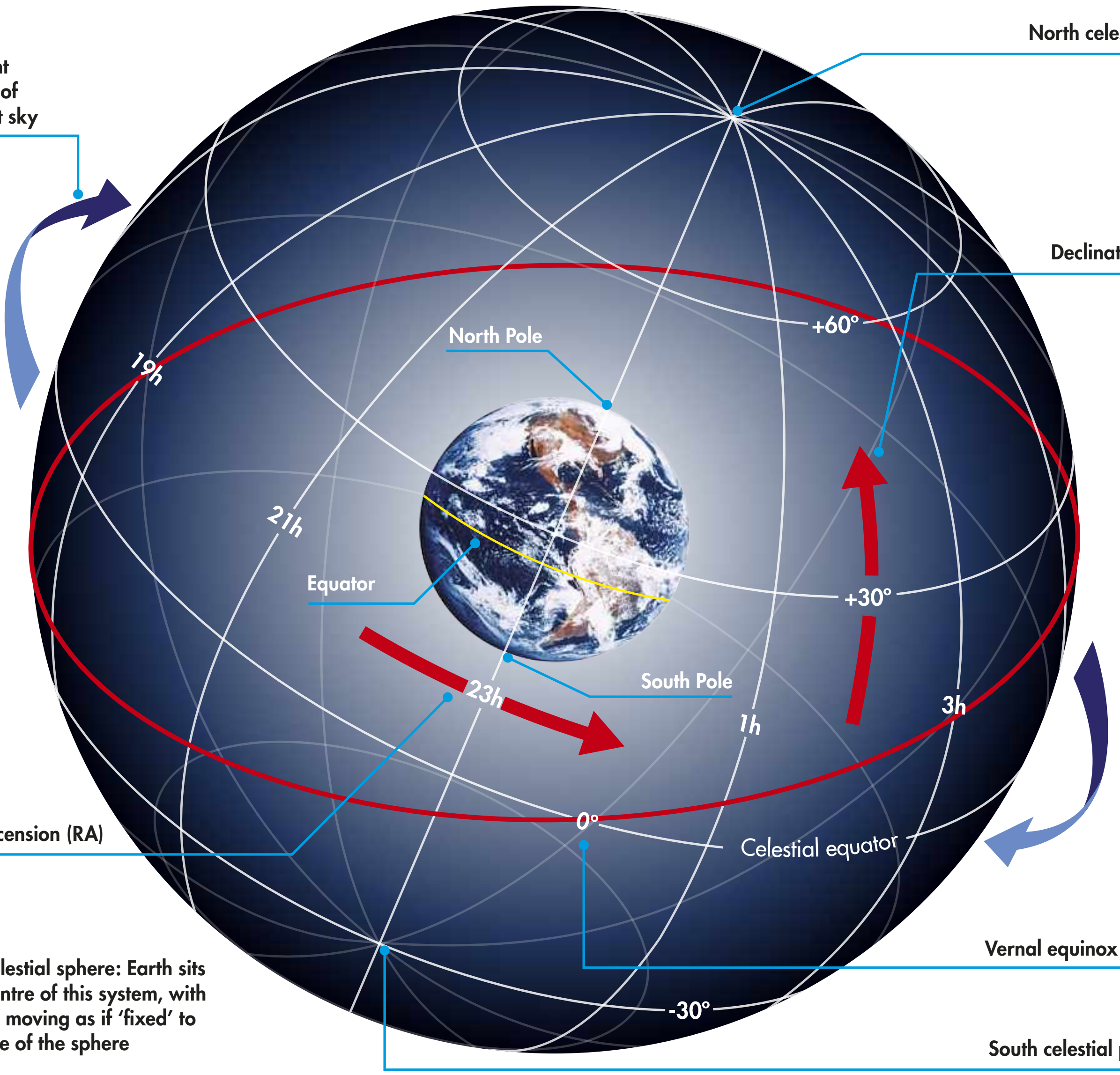
The Guide

Understanding the celestial sphere

With **Steve Richards**

How this imaginary construct allow us to find observing targets in the sky



► **The celestial sphere: Earth sits at the centre of this system, with the stars moving as if 'fixed' to the inside of the sphere**

Astronomers, in common with most other explorers, like nothing more than cataloguing their discoveries. When we log the position of a terrestrial object, it is convenient to use longitude and latitude as these are measured from the fixed reference points of the Greenwich Meridian and the equator respectively. However, these references don't work when it comes to pinpointing the location of stars, as to Earthbound observers the stars appear to move across the sky. Instead, we use the concept of a celestial sphere.

Imagine observing the night sky from one horizon, directly overhead at a point known as the zenith and then down to the opposite horizon: this gives the illusion of a dome with all the stars affixed to it, and this is the key to our celestial sphere.

Consider Earth as a sphere with north and south poles. The imaginary celestial sphere is similar: a larger sphere, in which the Earth sits at the centre, with north and south poles of its own. These poles, which we know as the north and south celestial poles, the NCP and SCP, are positioned above their Earthly counterparts.

If you were to stand on Earth's north pole and look directly upwards, you would

be looking at the NCP, and the reverse applies to the SCP. By happy coincidence there is a mag. +2.0 star very close to the NCP; this star is Polaris, the alpha star of Ursa Minor, and it acts as a marker for the location of the NCP from any location in the northern hemisphere.

Your location matters

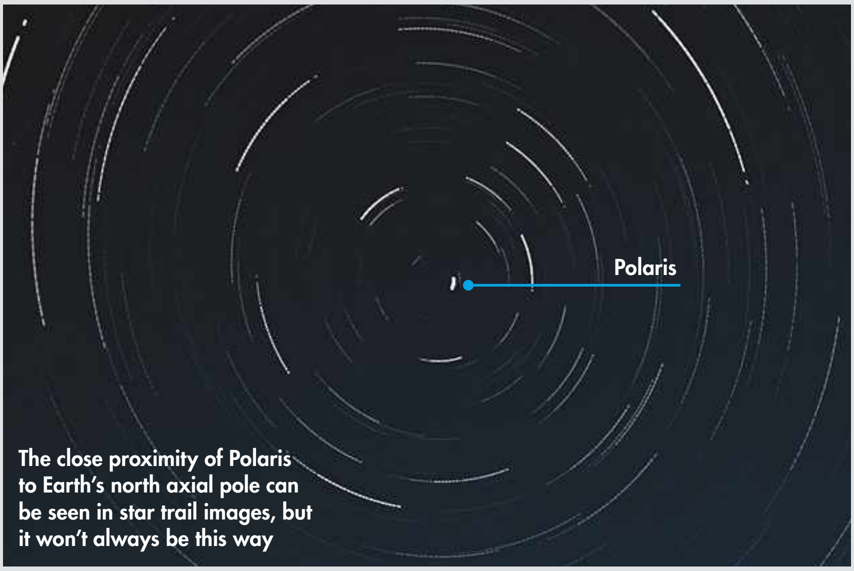
Directly above Earth's equator lies the celestial equator, an imaginary circle that divides the celestial sphere in half. Observing the horizon from the poles would show stars located on the celestial equator. Observing from Earth's equator, the celestial equator would stretch from the eastern horizon to the western horizon in an arc directly over your head, and the celestial poles would lie at your northern and southern horizons. Wherever you observe on Earth, you can only see a hemispherical dome at a time.

Over the course of a year, observers at the equator will see the whole celestial sphere, whereas those at the poles only ever see their respective half of the sphere.

Setting circles can help you to track down targets in lieu of a Go-To

WHY ASTRONOMERS NEED **RA AND DEC**

Many popular targets are small or dim, making them difficult to locate through the eyepiece even with star hopping. Using RA and dec. coordinates allows us to easily locate these more elusive objects. The coordinates for a given target can usually be found from various sources: in our *Sky Guide* or on star charts; online via a web search; or through planetarium programs or apps. If you have a Go-To mount, it will be able to calculate the position of any objects in its database and automatically point to the correct place in the sky. However, you can also use the setting circles on many manual equatorial mounts. Start by locating a bright star that is easily visible and close to your intended target; dial in the star's coordinates carefully and check its position. Move the scope in RA and dec. until they match the coordinates of your target; it should now be visible in a low-magnification eyepiece.



The close proximity of Polaris to Earth's north axial pole can be seen in star trail images, but it won't always be this way

EARTH'S PLACE **WITHIN THE SPHERE**

Although Earth is at the centre of this construct, our relationship with the celestial sphere is not fixed due to a process known as the 'precession of the equinoxes' or simply 'precession'.

The gravitational influence of the Sun, Moon and (to a much lesser extent) the planets of the Solar System tug at Earth, causing it to 'wobble'. This wobble completes a full cycle approximately every 26,000 years, during which time the positions of the stars change both equatorially and ecliptically. Currently, Earth's north axial pole extends to a point 0.7° from the star Polaris, but this hasn't always been the case and won't be so in the future.

Changing at about 1° every 72 years, in about 2,000 years' time our pole star will be Errai (Gamma Cephei), followed by Alderamin (Alpha Cephei) in about 5,500 years. In 12,000 years' time it will be Vega (Alpha Lyrae) – though none of these stars will sit as close to the NCP as Polaris is now.

At any point between the poles and the equator, you would see some stars from both halves.

The coordinates used to locate stars on the sphere are known as right ascension (RA) and declination (dec.). Declination is the number of degrees the object is located above or below the celestial equator. Right ascension is an angular measurement in hours, minutes and seconds eastwards from a point known as the vernal equinox. This is the location of the Sun on the celestial sphere at the point that it crosses the celestial equator at the March equinox – the date in March when day and night are equal in length.

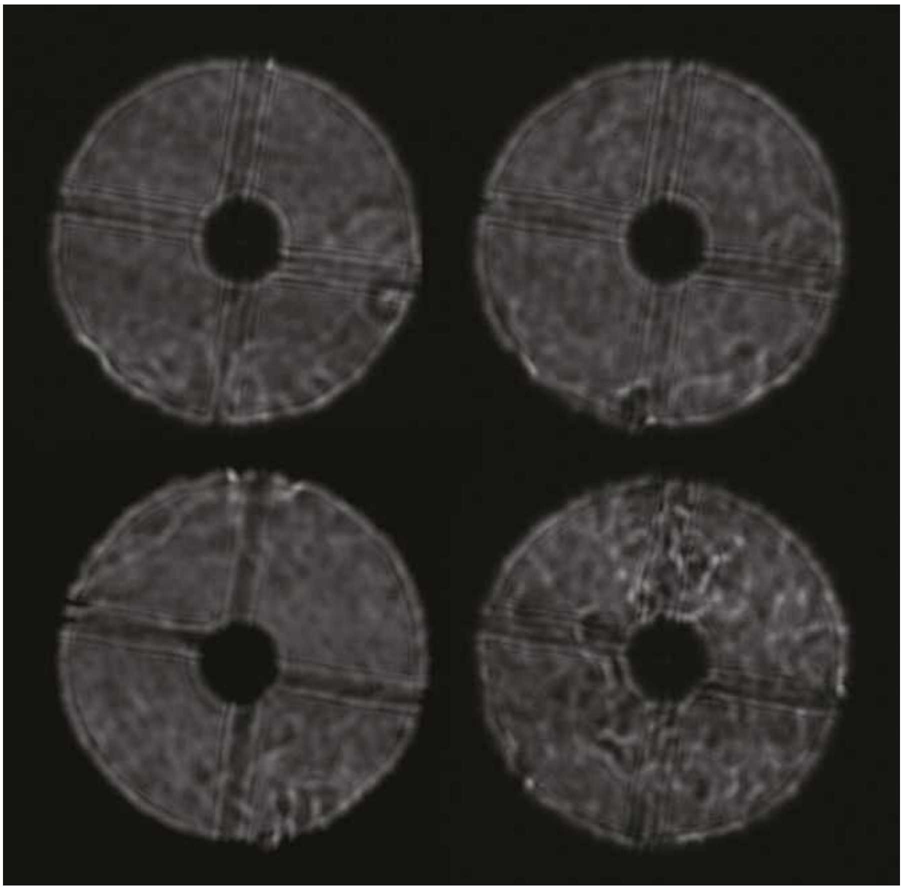
Although star positions are for our purposes 'fixed' on the celestial sphere, those of the Sun, Moon and planets are not. As Earth spins on its axis, the Sun appears to traverse the sky in a plane known as the ecliptic. Because Earth's axis is tilted at an angle of 23.5° with respect to its orbit around the Sun, the ecliptic too is tilted at the same angle with respect to the celestial equator. The planets orbit the Sun in a similar plane to Earth so the ecliptic also marks the region of the sky where the planets can be observed.

Steve Richards is a keen astro imager and an astronomy equipment expert

How to
Thermally optimise your telescope

With Martin Lewis

We show you how to combat the irritating effects of tube currents



▲ **Image-disturbing tube currents can be seen silhouetted against the greatly defocused image of a bright star; the currents appear as slow swirls trapped within the disc**

TOOLS AND MATERIALS

FANS AND BATTERIES
For Newtonian mirror cooling choose a low-vibration ball bearing or Hydro Wave bearing DC computer fan. Power the fan from an external power supply or an onboard battery pack.

RADIATOR FOIL
The aluminised insulation sold to fit behind radiators or line lofts can also be used on the outside of a telescope tube.

SPACE BLANKET
Aluminised Mylar space blanket is an alternative to radiator foil and can be bought from camping and outdoor shops. Ideally, use both products.

TOOLS
Scissors and insulating tape will be needed to cut and hold the radiator foil and space blanket in place.

Thermal dynamics can have a big influence on the views you get through your telescope, blurring planetary detail, distorting star images and degrading contrast in detailed objects such as globular clusters. If you really want the best performance – whether you are imaging or observing visually – it is worth getting to grips with these issues so you can minimise their impact.

Inside a cooling telescope, the warmer (less dense) air rises from hotter parts of the instrument as they lose heat by convection. These 'tube currents' are trapped inside the telescope and, because the warmer air has a different refractive power than the cooler air, they introduce differing delays to light passing through. This upsets the ability of the telescope's optics to bring the light to a sharp focus.

The longer the optical path inside the telescope and the more unequal the air temperatures, the greater the problems caused by tube currents are. For a scope with a 1m focal length, even a 0.1°C temperature difference over the length of the scope is enough to degrade images.

Larger telescopes are more affected than smaller ones due to their longer light path, but also because they have a smaller ratio of area to mass, meaning they take longer to cool down. Reflectors also tend to suffer more than refractors because light has to make one passage of the tube before being collected by the mirror and bent inwards away from the tube walls, where the worst convection currents often lurk.

In principle, to eliminate the problematic convection currents you just need to allow all parts of your telescope to cool to ambient temperature. Thermal effects really subside when the optics and other parts inside your telescope have a less than 1°C difference to the ambient temperature. When within 0.5°C, not only do the tube currents die right down, but the layer of warmer unstable air that is otherwise tenaciously stuck to the front of the mirror or primary lens almost completely melts away – allowing maximum optical performance.

Unfortunately, getting the scope to cool down sufficiently is often not so easy. If it has been stored in the warmth indoors, ▸

▲ Insulating material like this space blanket can stop your scope cooling too much

▸ then taking it out into the cold night air and expecting it to perform at its best straight away is a mistake. It is much better to store it outside the house before use and allow it to cool down properly beforehand.

A small or medium telescope might cool down fully in 30 minutes, but a large one can take several hours to properly acclimatise. Because air temperatures usually continue to fall through the night, the scope may stubbornly remain a few degrees above ambient. Big telescopes also have big mirrors, and the large mass and the poor conductivity of glass mean they don't give up their heat readily. Fans blowing gently on the back of the mirror can really help here.

After cooling actions

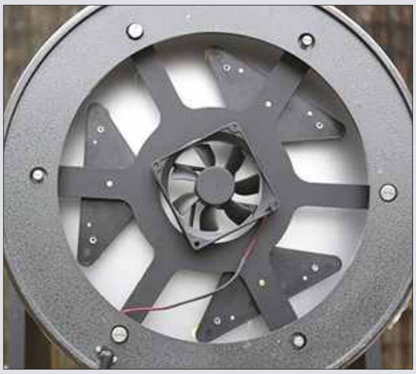
Even if the scope has lost all of its heat to the air, you can still get convection issues of a different kind. Parts of the telescope that face the radiatively cold night sky, particularly the top face of the telescope's tube, can drop several degrees below ambient temperature, inducing convection currents of cold air that continually cascade down inside the tube. Unlike normal tube currents, which tend to die down with time, such 'inverse' tube current processes can plague you all night. The good news is you can combat such effects by wrapping parts of your scope in a poorly radiating material such as shiny aluminium or add a layer of insulation.

The best way to check for any residual thermal issues before starting to observe is to perform a star test where you rack an eyepiece well inside focus. This allows you to clearly see any thermal currents in the tube silhouetted against the bright expanded disc of the defocused star.

By following the steps to the right, you will see how badly thermal issues affect your telescope and will hopefully be able to reduce their severity to give you sharper views of the night sky.

Martin Lewis is a keen astronomer and regular *First Light* reviewer

STEP-BY-STEP GUIDE



STEP 1

You can speed up the cooling of a Newtonian mirror by fitting a DC fan to the rear cell so that it blows onto the rear face of the mirror. If possible, mount the fan on soft rubber washers or string it between elastic bands to isolate its vibrations.

STEP 2

A low-tech alternative to fitting an internal fan is to place a free-standing fan nearby, blowing on the mirror end. This will help to get it closer to ambient temperature, at least until you start your observing session.

STEP 3

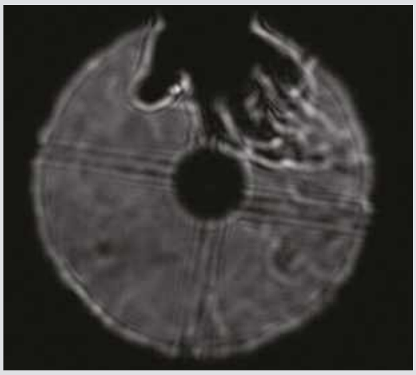
Allow plenty of time for the scope to acclimatise to the outside temperature before use. To help speed things up, store your telescope in an unheated place, like a shed or garage, when not in use. If it is stored in a warm place, it will need longer to cool.

STEP 4

Fit the scope with a layer of aluminised radiator foil to reduce inverse tube currents caused by the chilling effect of the cold night sky, especially during still and transparent nights. This will ensure the exposed parts of the tube stay closer to ambient temperature.

STEP 5

Another way of reducing inverse tube currents is to wrap Mylar space blanket around the body of your scope. Like the more permanent insulated foil, this reduces the radiative chilling of the telescope by the night sky.



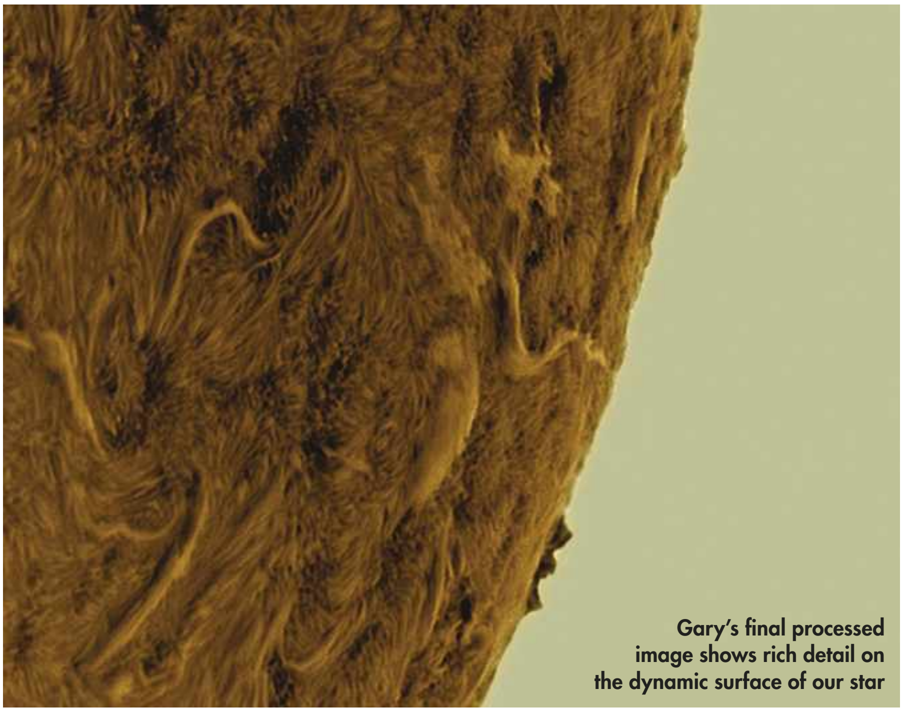
STEP 6

Rack the eyepiece far inside focus to expand the image of a bright star to one-third of the field diameter. Tube currents will be seen as swirling patterns of bright and dark, trapped within the circular disc. Experiment using your hand at the front end to see the currents.

Image processing

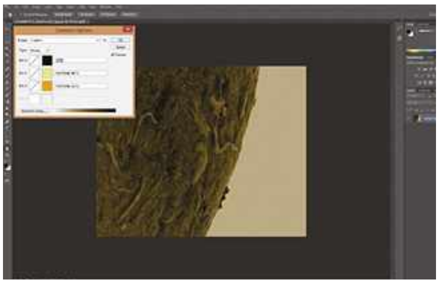
Colouring the Sun

With **Gary Palmer**



Gary's final processed image shows rich detail on the dynamic surface of our star

▲ In Variations, click on a colour more than once to incrementally add more to your image

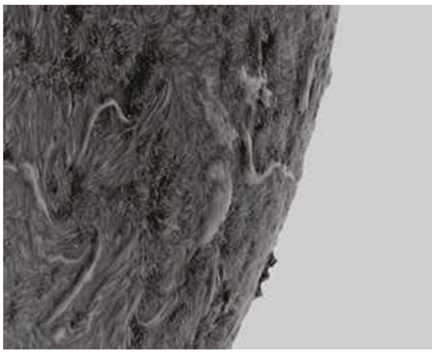


▲ In Duotone, always keep black as one of your inks to maintain contrast

The quality of solar images produced by amateurs has come a long way in the past few years, so much so that they are comparable to some satellite images. While solar telescopes have stayed pretty much the same, cameras have evolved massively.

Many astronomers start out in solar imaging using hydrogen-alpha telescopes and colour cameras, and they have a hard time gaining detail in their images. This is because of the narrowband nature of the scope, which means a colour camera only uses a fraction of its chip. Monochrome cameras produce much more detailed images, as they can make full use of their sensors. Of course, to achieve a colour image, we need to use processing software.

Colourised mono images are often described as having 'false colour', and most of the time this is added in a program such as Photoshop or GIMP. The final colour you pick is a matter of taste, but you have to be careful not to oversaturate the colour as this will lead to a loss of detail. As a guide, lighter colours such as pale yellow and a pale orange work best for keeping detail in the final image; darker reds can hide it, particularly around sunspots.



▲ Your starting shot should be monochrome; the final colour you choose is up to you

There are two ways to add colour in Photoshop. The first is to use Variations (Click Image > Adjustments > Variations) – note this option is only available on Mac OS when running Photoshop in 32-bit mode.

A new panel will open and the colours can be added by clicking on the required red, green or blue tabs. A live view of the colour can be seen at the top of the page, in the screen named 'Current Pick'. Fine amounts of colour can be added by clicking multiple times on a colour. Further changes can be made afterwards using Colour Balance (Image > Adjustments > Colour Balance).

The second way is to use a process called Duotone; if you are processing tiff images, you'll need to convert them to 8-bits for this to work. Do this by clicking Image > Mode > 8Bits/Channel.

Tiff or not, the image also needs to be greyscale to start with (Image > Mode > Greyscale). Now you can set it to Duotone (Image > Mode > Duotone), which will open the Duotone options dialog box. In these options, change the type tab from Monotone to Tritone.

This allows you to pick three tones for your image. Black is automatically in the first slot, and you need to keep it to maintain contrast. Select one of the blank boxes and choose a suitable colour; repeat for the second. When done, you will need to turn the image back to RGB colour (Image > Mode > RGB Color). If you are working on a prominence and a separate surface image, do not combine the layers when asked. As with the previous technique, colour balance can now be used to adjust the colours for each layer to your preference.

Gary Palmer is an expert solar imager. See more of his shots at www.solarsystemimaging.co.uk

ALL PICTURES: GARY PALMER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STEVE'S TOP TIP

What is focal length?

Focal length is one of several parameters that make up the specification of a telescope. It denotes the effective distance that the light received from a distant object travels from the primary optic (the concave mirror of a reflector or the lens of a refractor) to the focal plane, which is the point at which the light is focused.

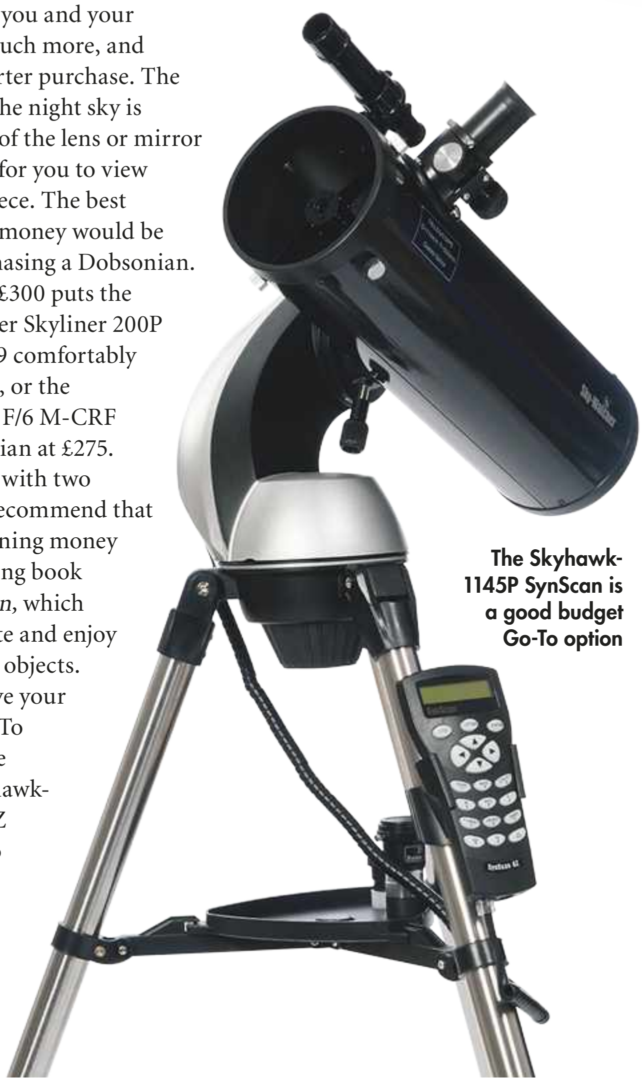
The practical significance of focal length is that, with any given eyepiece, long focal lengths produce a narrower field of view and greater magnification, while short focal lengths produce a wider field of view and lower magnification.

What is the best telescope for a family of beginners with a budget of £300? JIM EDWARDS

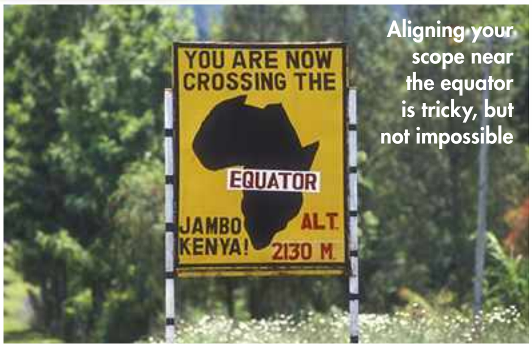
Although you may be tempted to buy a telescope and mount with all sorts of electronic wizardry built in, I would caution against this with your budget: a larger telescope with no frills would allow you and your family to see so much more, and would be the smarter purchase. The key to observing the night sky is aperture, the size of the lens or mirror that collects light for you to view through the eyepiece. The best aperture for your money would be obtained by purchasing a Dobsonian.

Your budget of £300 puts the 8-inch Sky-Watcher Skyliner 200P Dobsonian at £279 comfortably within your grasp, or the Revelation 8-inch F/6 M-CRF Premium Dobsonian at £275. Both are supplied with two eyepieces, so I'd recommend that you use the remaining money to buy the observing book *Turn Left At Orion*, which will help you locate and enjoy your first celestial objects.

If you really have your heart set on a Go-To telescope, then the Sky-Watcher Skyhawk-1145P SynScan AZ Go-To, which also comes with two eyepieces and did well in our tests is right at the top of your budget but has a much smaller aperture of 4.5 inches. Alternatively at about £30 over your budget, the Celestron NexStar 130 SLT, with a single eyepiece but a larger aperture of 5 inches, would also be a good choice.



The Skyhawk-1145P SynScan is a good budget Go-To option



Aligning your scope near the equator is tricky, but not impossible

While on safari with my Vixen Polarie Star Tracker I had trouble avoiding trailing. Is it more difficult to polar align at the equator? STEVE BOSLEY

It's extremely difficult to accurately polar align at the equator, and typical 'signpost stars' – Polaris in the northern hemisphere and Sigma Octantis in the southern hemisphere – will not be visible. Performing a full drift alignment is time-consuming and probably not ideal when you are on safari!

It's most likely that to align your scope you used the Polarie's inclinometer to set the elevation to your safari latitude, and the supplied compass to align to the South Pole. Your poor results would indicate a calibration error, most likely in the compass heading. Most locations on Earth require a correction for 'magnetic deviation/declination' which can have a significant effect on compass accuracy.

The magnetic deviation for any location on Earth can be found at **www.ngdc.noaa.gov/geomag-web/#declination**. Deviation to the west should be subtracted from the compass bearing and deviation to the east should be added to the compass bearing.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com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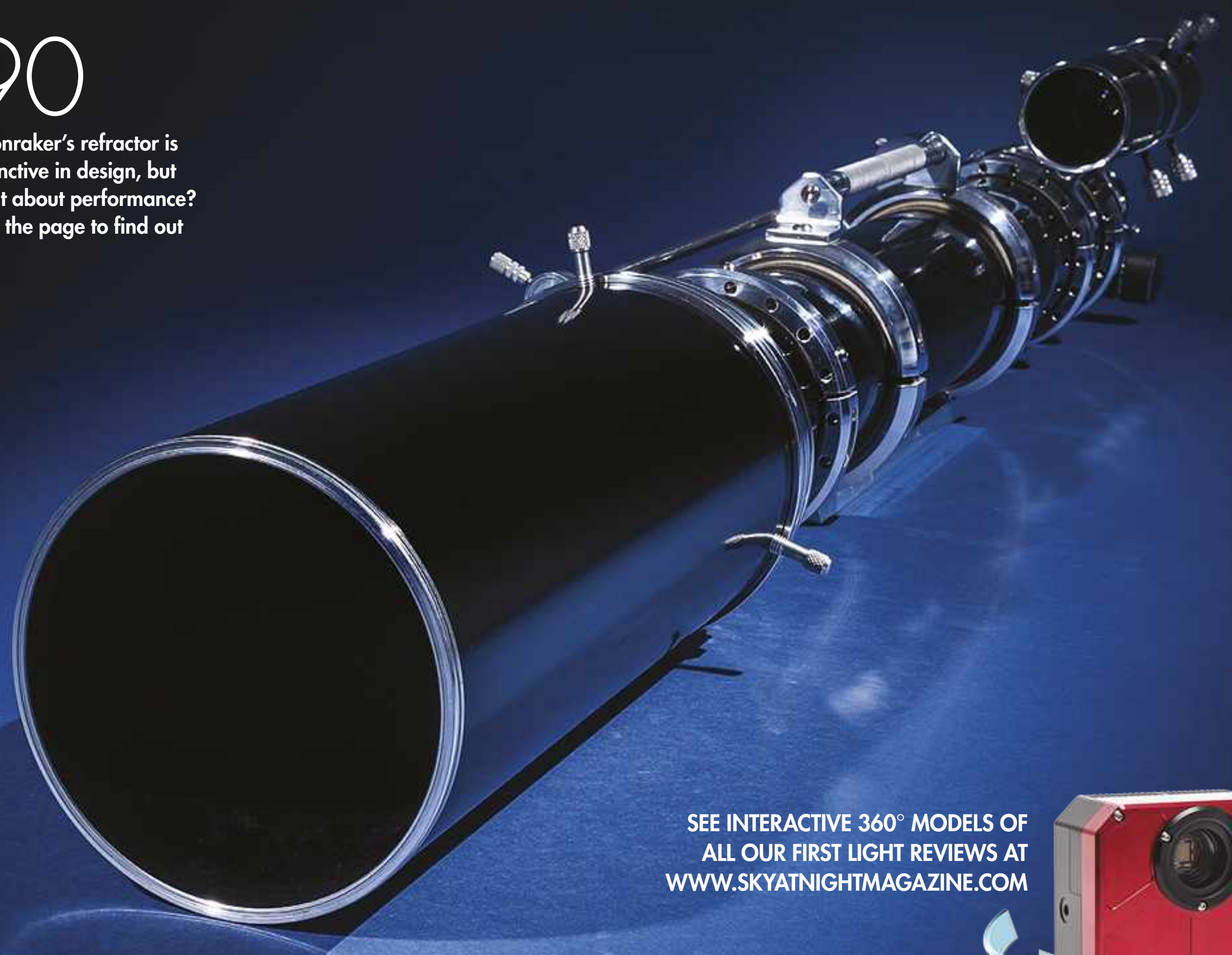
Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

- ★★★★★ Outstanding
- ★★★★★ Very good
- ★★★★★ Good
- ★★★★★ Average
- ★★★★★ Poor/Avoid



90

Moonraker's refractor is distinctive in design, but what about performance? Turn the page to find out

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This month's reviews




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FIRST **light**

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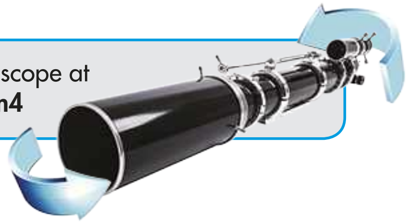

Moonraker Nebula Class 4-inch f/12 refractor

A striking telescope that could be destined to be a classic

WORDS: STEVE COLLINGWOOD

SKY SAYS...
The optics gave great views with very little false colour and excellent contrast

VITAL STATS

- **Price** £2,200 + VAT
- **Optics** Istar optical achromatic doublet
- **Aperture** 100mm (4 inches)
- **Focal length** 1,200mm (f/12)
- **Focuser** 2-inch dual-speed rack and pinion
- **Extras** 50mm optical finder, 2- to 1.25-inch adaptor
- **Weight** 7kg
- **Supplier** Moonraker
- **www.moonraker telescopes.co.uk**
- **Tel** 01932 874146

ALL PICTURES: WWW.THESECRETSTUDIO.NET

At a time when small, short focus apochromatic refractors are all the rage, it comes as quite a surprise to see a long focus achromatic refractor enter the market. Moonraker's Nebula Class 4-inch f/12 instrument certainly stands out from the crowd.

Modern mass production techniques and developments in glass types have revolutionised the way telescopes are made, and indeed made high-quality telescopes more affordable than ever. From the sleek black gloss powder coat finish to the highly polished aluminium fixtures, this telescope certainly looks unique.

The refractor ships with Moonraker's own tube rings and dovetail bar. These are hand made and beautifully finished, and they contribute to the overall look of the telescope in no small measure. The supplied carry handle also attaches to the tube rings. Unlike many of today's high-end refractors, no hard case is included.

We found the Vixen/Synta profile dovetail bar allowed a good solid connection to our mount, though given the weight and size of the telescope it would be useful to have the larger 'D' type Losmandy-style dovetail bar as the majority of medium to large mounts use this bar for stability. This is a minor quibble, however. The supplied rack and pinion focuser proved positive and robust, holding a wealth of eyepiece and diagonal combinations without slipping.

Journeys around the heavens

We took the scope out under the night sky with our own star diagonal and a selection of eyepieces, and found that it delivered beautifully crisp images. The contrast was excellent, even under a moonlit sky. The telescope tube is both internally flocked and baffled. The extra-long dew shield is also internally flocked, ensuring that valuable photons are ▸

ARTISAN HANDCRAFTING

Handcrafted and distinctively styled, the Moonraker stands out from the first glance. Excellent build quality and attention to detail ensure a package that not only performs well, but is undeniably a custom instrument. Mounted to the top of the tube assembly is the carry handle, and given the length and weight of the telescope this is a really useful addition. Lifting the tube into position to attach to the mount can be quite tricky with larger instruments, so anything that helps to avoid accidents is always welcome. Even here, using a knurled finish not only gives the handle a distinctive look, it also ensures a surface that is easy to grip. The balance weight is nice and functional while yet again fitting the sleek and elegant design of the telescope perfectly. While these features may not be new to telescope making, they are well executed and uniquely presented, making this instrument instantly recognisable and very usable indeed. It draws much inspiration from vintage telescopes, but also moves forward and promises to be a future classic itself.

FINDER

The supplied 7x50 optical finder is a straight-through type using a Vixen primary lens and eyepiece. Well mounted in sturdy rings, it performed well – giving sharp stars and a wide field of view. The eyepiece has a crosshair that enables targets to be reliably centred.

TUBE RINGS

The highly polished aluminium fixtures and fittings not only look very striking, but are a key feature of the Moonraker design. The mounting rings are felt lined and reassuringly solid in construction, while the over-sized knurled thumbscrews allow adjustments to be made without fuss when wearing gloves.

OPTICS

The primary lens is hand figured by Istar Optical and has a broadband multicoating, giving it a slight yellow hue. It is a classic achromatic doublet design housed in a push-pull style lens cell. In use, the optics gave great views with very little false colour and excellent contrast.

FIRST **light**

BALANCE SYSTEM

Fitted as standard, the Nebula Class refractor has a small counterweight on a sliding rail attached to the body of the telescope. This allows the tube's balance to be quickly and easily adjusted when changing eyepieces or accessories of different weights. This is particularly useful with larger 2-inch eyepieces.

FOCUSER

The focuser is a rotatable rack and pinion unit with dual speed 1:10 ratio for greater focus control. It can accept both 2- and 1.25-inch eyepieces with the supplied adaptor. There are also options for customised Moonlite, Feathertouch or Baader focusers at additional cost.

SKY SAYS...
Now add these:

1. EQ6 or equivalent mount
2. Baader Maxbright binocular viewer
3. Custom storage case

▸ not lost by bouncing off reflective internal surfaces inside the tube.

The telescope shipped with a customised 50mm Vixen finder, which also delivered sharp images. It possesses an extra-long dew shield, and its large knurled thumbscrews made it very easy to align the finder with the telescope tube and make fine adjustment even with cold hands. The finderscope mounting brackets are reassuringly solid and screw directly to the mounting rings on the tube. The finder bracket is not removable, however, so care must be taken when transporting the instrument. One particularly nice feature is the ability to move between a single eyepiece and a binoviewer without the need for additional lenses or adaptors.

Using our own star diagonal and 26mm eyepiece we aimed at the Pleiades open cluster in Taurus: the stars were pin sharp across 95 per cent of the field of view. Moving to Vega in Lyra, we were impressed by a crisp, well-defined image that yielded extremely little false colour fringing. We tried increasing the magnification with a 3-6mm Televue Nagler zoom eyepiece, which delivered a tight, well-resolved star and airy disc. Taking Vega slightly in and out of focus revealed even concentric rings, showing a good alignment of the lens elements.

Moving over to the double star Alberio in Cygnus, we were greeted with a beautiful contrast of blue and gold. The colour rendition was superb even though the Moon was casting a bright glare at the time of review. And although the Moon was indeed very bright, the telescope was still able to deliver an exceptionally detailed view of the lunar surface, with a good tonal range even in the less than ideal observing conditions.

The Nebula Class refractor is certainly an observer's instrument through and through. Its unique styling helps showcase a beautifully tactile and practical instrument. Hand made to a very high standard, the design would not look out of place on the set of a 1950s sci-fi movie, yet it also manages to look modern at the same time. Daring to be different always carries a degree of risk, and while the Moonraker's appearance may not be to everyone's taste, this telescope is a great example of British design and practical craftsmanship. Ⓢ

VERDICT

BUILD & DESIGN	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★★
FIELD OF VIEW	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★★

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FIRST **light**

See an interactive 360° model of this mount at
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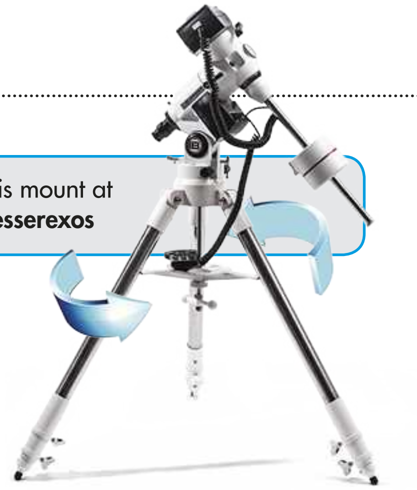

Bresser EXOS 2 Go-To mount

A sturdy mount that offers great tracking capability

WORDS: PAUL MONEY

VITAL STATS

- **Price** £499
- **Max capacity** 13kg
- **Tripod** Stainless steel with adjustable legs
- **Controller** Meade Autostar or Bresser Star Tracker
- **Database** 30,000 or 100,000 objects
- **Power** Eight D batteries or 12V mains supply
- **Extras** 4.5kg counterweight, Moon map, Stellarium software
- **Weight** 9.2 kg
- **Supplier** Telescope House
- **www.**telescopehouse.com
- **Tel** 01342 837098

WWW.THESECRETSTUDIO.NET X 5, PAUL MONEY X 2

The EQ5 is a German equatorial mount that has become the design of choice for use with medium-sized telescopes. Bresser's EXOS 2 Go-To mount continues in this tradition, and can be used for both visual observing and astrophotography.

The mount is supplied with a stainless steel tripod, hand controller, 4.5kg counterweight, accessory leg brace and a battery case that takes eight D batteries (which are not supplied). It also features an in-built illuminated polar scope. Assembly was reasonably straightforward, with the main body attaching to the tripod and the hand controller to the mount head.

The mount is solidly built and once attached to the tripod we found it a very sturdy base for a range of our own scopes, including a 3-inch f/5 apo refractor, a 5-inch f/9.4 achromatic refractor and a 7-inch f/15 Maksutov. The manufacturer recommends a maximum load capacity of up to 13kg for visual use; if you are considering this mount for imaging, we would suggest a load limit of 10kg for smooth tracking. The saddle is Vixen style, but for the sort of telescopes you would use with it this is no problem: its large knurled locking knob held all the telescopes we attached to it firmly and securely.

SKY SAYS... Our tracking and slew tests were very good and once on target the mount was very quiet

Setting up

Polar alignment was straightforward using the in-built polarscope and the latitude and azimuth adjustment bolts. The polarscope reticule has etched guides for both the southern and northern hemispheres, and an illuminator to help with the alignment process.

Power is supplied by either the aforementioned battery case or a 12V mains power adaptor (sold separately). Note that the power connector is not the same type commonly found on other popular mounts, but a suitable cigar type power lead with the correct connector can be purchased from the supplier. As we didn't have this cable, we used our own five-in-one power pack with inverter and a mains adaptor: even after four hours continuous use, we saw little drop in its power levels. It would be fair to say that this mount is not power hungry. ▸

TIGHT TRACKING

For our Go-To and tracking tests we chose the handset's three-star alignment option to get the best possible results then selected a range of objects to slew to and track. With our 5-inch f/9.4 achromat and our 26mm eyepiece we selected the Orion Nebula and pressed 'Go-To': the mount placed it almost spot on the centre of the view. We did this for the Cigar Galaxy in Ursa Major and again it was only just off centre. For a longer test, we placed the star Aldebaran in the centre of the field of view and left the system to track it. When we returned an hour later, Aldebaran had only drifted off centre by a small distance. After swapping to a 3-inch apo refractor and attaching a DSLR, we were able to record two-minute exposures with very little trailing.

▲ **Accurate Go-Tos allowed us to image the Orion Nebula, and the Horsehead and Flame Nebulae**

LATITUDE AND AZIMUTH ADJUSTMENT

Adjusting latitude and azimuth was comparatively easy even when wearing gloves on a frosty night. The latitude scale ranges from 0° to 90° and was easy to read as you carry out polar alignment. We also found the arrangement sturdy when everything was locked in place.

POLARSCOPE

Achieving accurate polar alignment is vital for ensuring accurate slewing and good tracking during long exposure astrophotography. The polarscope has an illuminated LED and a single graduated reticule for aligning with the pole. With with the aid of suitable computer software or a smartphone app, good alignment can be achieved.

TRIPOD

The variable-height field tripod has stainless steel legs with a spreader bar brace; the brace doubles as an accessory tray that can house two 1.25-inch eyepieces and one 2-inch eyepiece. Each leg also has two locking nuts for when the legs are extended. We found the tripod to be sturdy and stable.

HAND CONTROLLER

The hand controller of our review system was the Meade Autostar. It has a two-line red LED display and 30,000-object database, which includes the Messier, Caldwell and NGC/IC catalogues plus a host of other targets. It will soon be replaced with the Bresser Star Tracker (see above), which has a larger display and an expanded object database.

FIRST light

PORTS

The body of the RA axis houses four ports for connectivity in one convenient section: one for the hand controller, one for power, one for the dec. cable and an aux port for computer control or autoguiding.

▸ The hand controller supplied with the review mount was the Meade Autostar, which has red backlit buttons and a two-line red LCD screen. Its database contains more than 30,000 objects, plus a tour option and several alignment choices to help you achieve accurate slewing. For visual observing the 'easy' (where stars are selected for you) and two-star alignments were sufficient, but the three-star alignment gives more accurate slewing for astrophotography.

After the review period we learned that Bresser is replacing the Meade Autostar with another handset of its own design, the newer Bresser Star Tracker. This hand controller features a larger, easier to read LCD screen, with an eight-line display and a dedicated ST-4 port for guiding purposes. The object database is also larger, with 100,000 objects as opposed to the Meade Autostar's 30,000. Telescope House has told us that they will be selling the EXOS mount with the Bresser Star Tracker as soon as it becomes available.

In action, the mount performed well: our tracking and slew tests were very good (see 'Tight tracking', page 94) and though we did find the high slew rate to be quite noisy, once on target the mount was exceedingly quiet. We can certainly recommend the EXOS 2 for beginners and intermediate users alike, being simple to set up, accurate in operation and a joy to use. Ⓢ

SKY SAYS...
Now add these:
1. Tracer 12V 10Ah lithium polymer battery pack
2. Cigar type power lead plus connector
3. Revelation-Synta CNC dovetail bar

VERDICT

ASSEMBLY	★★★★☆
BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★☆
TRACKING ACCURACY	★★★★☆
STABILITY	★★★★☆
OVERALL	★★★★★

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FIRST **light**

See an interactive 360° model of this camera at **www.skyatnightmagazine.com/atikone6**

Atik One 6.0 CCD camera

A built-in filter wheel completes a package likely to tempt those looking to upgrade

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £2,336
- **Sensor** Sony ICX 694 (2,750x2,200 pixels)
- **Readout noise** 5e
- **Sensor size** 12.5x10mm, 16mm diagonal
- **Backfocus distance** 27mm
- **Weight** 900g
- **Supplier** Atik cameras
- **www.**atik-cameras.com
- **Tel** 01603 740397

SKY SAYS... It is an absolute joy to have a built-in wheel that presents each filter to the sensor in turn, under software control

Monochrome CCD cameras are a very popular choice for astro imagers as they provide a sensor that can be used in conjunction with a wide range of filters, which means you can capture all kinds of details in deep-sky objects. Normally, the filters need to be housed in an external filter wheel, but the Atik One 6.0 dispenses with this by incorporating an automated wheel within its casing. It is a very elegant solution.

To produce a colour image using a mono CCD camera, it is necessary to take a minimum of three sets of images: one with a red filter, one with a green filter and one with a blue filter. Combining these images produces an RGB colour image.

It is common to capture a fourth set of images at longer exposures using a 'luminance' filter to collect the structural detail at all wavelengths. This luminance data is then overlaid with shorter-exposure colour data to produce an LRGB colour image. While this is fine in theory, manually replacing each filter in turn is fraught with difficulty, so it is an absolute joy to have a built-in filter wheel that rotates to present each filter to the sensor in turn, under software control.

The Atik One is very compact, measuring just 120mm square by 58mm deep, and its attractive finish and chamfered corners give it a solid, quality feel. Included in the printed retail box are a multi-product installation manual, CD of software and drivers, 12V cigar lighter cable, USB cable, 2-inch nosepiece, Allen keys and a tool to insert filters into the internal filter wheel. The power cable's plug connects with a reassuring click – there is no need to worry about it becoming dislodged mid-session.

A matter of control

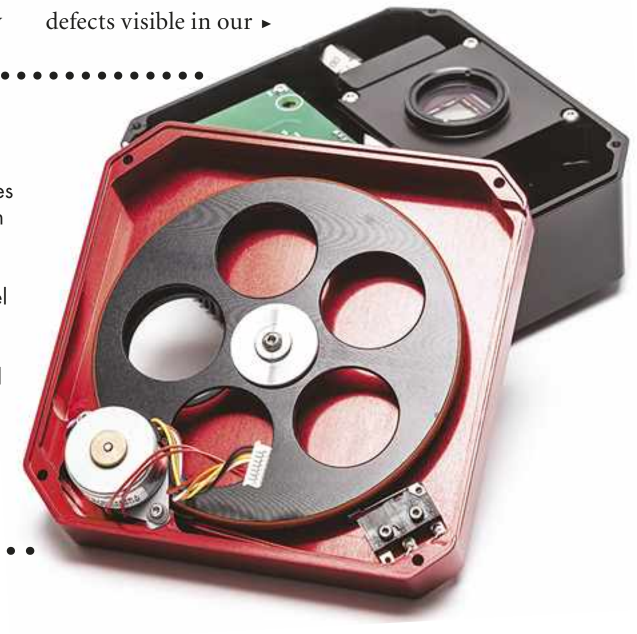
Installing the software and drivers was very straightforward. We tested the camera with both the simple but excellent Artemis Capture software supplied on the CD and our own version of MaxIm DL. Drivers specific to MaxIm DL, CCDSoft and AstroArt are included on the CD. However, the filter wheel itself can only be controlled using ASCOM when using any of the above programs. As such, we exclusively used ASCOM to control both the camera and filter wheel during the review.

Although Sony CCD sensors are renowned for their low thermal noise, it is still necessary to keep them cool. We set the cooling temperature to 20°C below ambient; with an air temperature at 12°C, it took just two minutes and 45 seconds to reach our goal temperature. Test images captured both before and after cooling confirmed that it was working well. There were no column defects visible in our ▸

ACCURATE FILTER WHEEL

The Atik One 6.0 has an integrated filter wheel with a carousel mounted on axial needle roller bearings. Incorporating a filter wheel into a CCD camera has some useful advantages. External filter wheels add considerably to the backfocus of the system, causing spacing difficulties when also using focal reducers, field flatteners or coma correctors. The integrated filter wheel here only adds 14mm to the depth of the camera, giving a total backfocus of 27mm. As most correctors are designed for use with DSLR cameras – which have a total backfocus of nominally 55mm including their adaptor rings – this leaves a generous 28mm for the insertion of an off-axis guider as well, if required. It also means you need fewer cables, as the power and USB leads for the filter wheel are shared with the camera.

The filter wheel has five 1.25-inch slots and it is vital that these are centred accurately in front of the sensor as each filter is chosen in turn. During our bench testing, we found that the filters were very accurately positioned and repeatability was excellent.



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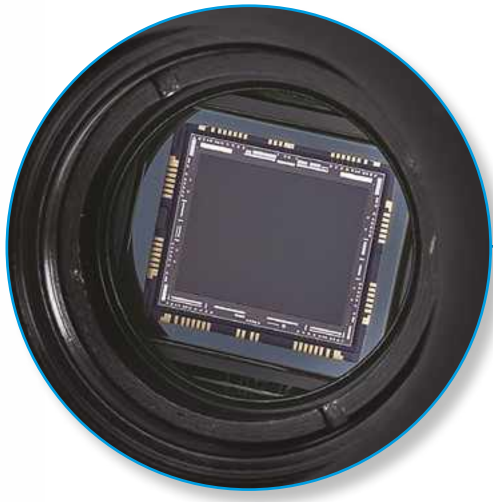


CCD SENSOR

The Sony sensor is 12.5x10mm, yielding a 16mm diagonal. Each individual pixel is 4.544μm^2, giving a total of six megapixels on the sensor surface. Despite this generous size the camera uses 1.25-inch filters.

SET-POINT PELTIER COOLING

It is important to keep the sensor as cool as possible to reduce the thermal noise produced during long exposures. The Atik One 6.0 possesses a single-stage Peltier thermoelectric cooling system with twin external fans and set point cooling control; these can cool the sensor to as low as 38°C below the ambient temperature.

ALLOY CASE

The camera's case is beautifully machined from aluminium alloy block and the whole back panel comprises a heat sink to help with cooling. The case includes two camera tripod threads and a female T-threaded adaptor at the front that can be removed for the attachment of an optional off-axis guider.

FIRST light

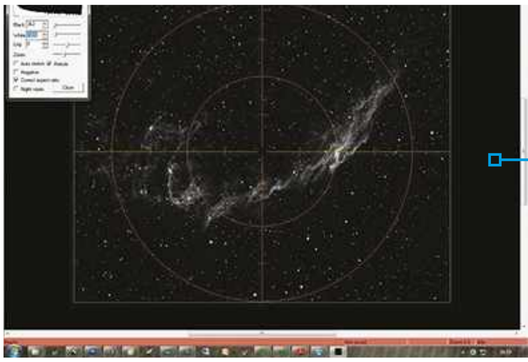
SKY SAYS...
Now add these:
1. Atik off-axis guider
2. Atik GP guide camera
3. Baader LRGB filter set

CONNECTIONS

The camera's bottom panel houses a range of connections: a 12V input; 12V auxiliary output for external devices; USB 2.0B connection; and a USB hub connector for controlling additional devices, such as a guide camera. Surprisingly, the functions of these ports are not labelled.

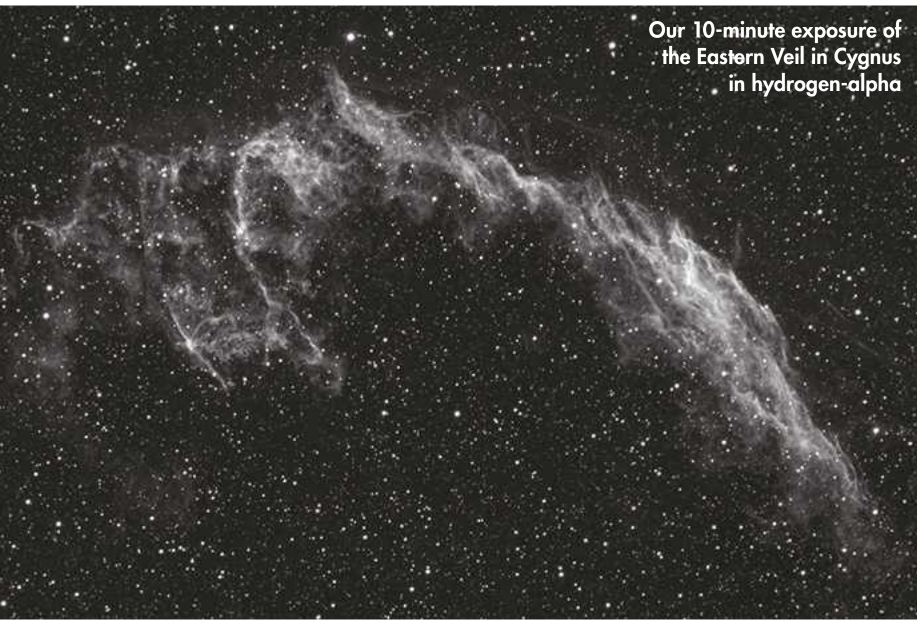
CONTROL AND PROCESSING SOFTWARE

The supplied CD includes Artemis image capture software (pictured), which gives full control of the camera and allows you to schedule a sequence of multiple image capture routines. Also included is the rather quirky image processing package Dawn, which can be used to calibrate, align and stack images.



▸ 600-second dark frames and just a few hot pixels were visible. We used these dark frames to remove thermal noise from the images captured by the camera.

We populated the filter wheel with a set of LRGB filters and placed a hydrogen-alpha (Ha) filter in the fifth slot, with a view to blending some Ha data into the red data collected from some emission nebulae. Inserting the filters was a little fiddly, but once installed they were well protected and firmly held in place. Unfortunately, appalling weather during the November review period thwarted our imaging plans but we captured Ha data on the rare occasions that we had a clearish sky. The camera performed excellently, producing a field of view 1° and 24 arcminutes wide and 1° and 7 arcminutes deep



Our 10-minute exposure of the Eastern Veil in Cygnus in hydrogen-alpha

when used in conjunction with a 4-inch refractor reduced to a focal length of 509mm. This gave us an ample field to capture the lovely Eastern Veil in Cygnus (NGC 6992) using 10-minute exposures.

The Atik One 6.0 performed faultlessly during the review period, producing low noise images and capturing plenty of detail. This camera will appeal to many imagers, but especially relative beginners because it is an 'integrated' solution that avoids some of the spacing issues that occur when using focal reducers and similar accessories. As the sensor is larger than many 'starter' CCDs, it should also suit intermediate imagers who have cut their teeth on a small CCD sensor. Ⓢ

VERDICT

BUILD AND DESIGN	★★★★☆
CONNECTIVITY	★★★★☆
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGING QUALITY	★★★★★
OVERALL	★★★★☆

WWW.THESECRETSTUDIO.NET, STEVE RICHARDS X 2

Books

New astronomy and space titles reviewed

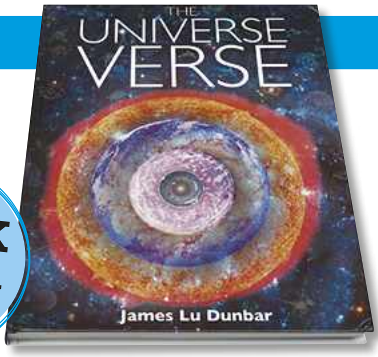
RATINGS
★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

You can order these books from our shop by calling 01803 865913

The Universe Verse

James Lu Dunbar
James and Kenneth
£22.99 ● HB

BOOK OF THE MONTH



Like the book it is about, this review is entirely written in verse.

It's always nice from time to time to read a book that's written in rhyme. And being a comic it's easy to read, so one can get through it very quickly indeed.

At the start of the book we meet two friends / and they stay with us till the journey ends. / There's a striking resemblance from just a quick glance, / to Albert Einstein – though perhaps it's just chance...

They're constant companions on our cosmic travels, / and they add to the fun as the story unravels. The adventures of Einstein and his female buddy / give extra levels of detail for us to study. While the book is initially black and white, / as the story develops it bursts with light.

In case your reading has interruptions, / this book is split into three main sections. / The author begins with early cosmology, / using clear, fun pictures and helpful analogy. He skips over most of our long cosmic history, / and the rest of the book explains life's mystery.

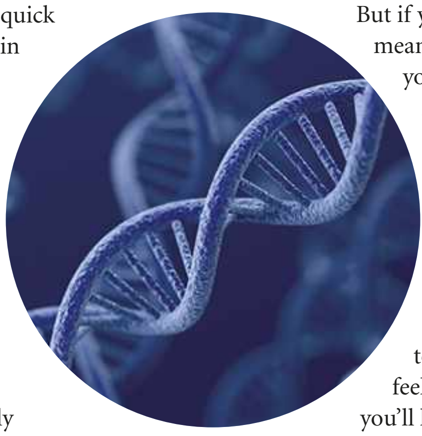
Part two of three describes the birth of the one and only planet Earth, at first describing the early geology, then moving on to more complex biology. / We start with life and it's first emergence, / and end with evolution and its infinite divergence.

The third book looks at the special case of our own ingenious human race. / The transition from slimy gelatinous gloop, / to our upright, technology-wielding troop. It's not just a case of the biochemistry; there's also historical anthropology.

With such eye-catching pictures gracing its pages, / this book is one for all the ages. But if you think the style means it sticks to the basics, you'd be wrong: it delves into some pretty deep physics. And it certainly doesn't shy away, from describing the details of DNA.

But don't be too worried about feeling a fool, you'll have heard most of the words in your classroom at school. There may be the odd term you don't understand, / but – rest assured – the pictures provide a helping hand.

★★★★★



Much science is covered in the rhyming way, from astrophysics to DNA

CHRIS NORTH *is a presenter on* The Sky at Night, *the Herschel outreach officer and, when inspiration strikes, a poet*

Reader price £19.99, subscriber price £18.99 P&P £1.99 Code: S0215/3 (until 25/03/15)

TWO MINUTES WITH JAMES LU DUNBAR

What inspired you to write the book?
A lifelong love of science, art and books, and a desire to make the world a better place. One very specific inspiration was the rhyming, illustrated books of Dr Seuss. Growing up I loved his books, and as I grew older I came to appreciate that some of them were actually about quite mature topics. I liked how he was able to take seemingly adult subjects and use rhyme and illustrations to present them in a way that children enjoy, and I've always aspired to do something similar myself.

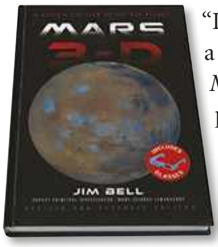
Was it challenging to write in verse?
Most certainly! Writing quality verse on such technical topics was not easy. Finding the words that rhyme is the obvious challenge, but then comes the matter of getting them to fit into a successful rhythm. There were some sections I had to rewrite over and over again to get them just right.

Have you always had an interest in space?
I think one of the most amazing truths a person can realise is that the night sky holds gigantic nuclear fireballs that are so very huge, but so very, very far away that they look like little specks of light from here, and that their light took millions of years to travel here so we're looking into the history of the Universe whenever we look up into the darkness. So yes, I've always thought space was very cool.

JAMES LU DUNBAR *is an artist and science enthusiast*

Mars 3-D

Jim Bell
Sterling
£14.99 ● HB



"I loved 3D pictures as a kid," writes Jim Bell in *Mars 3-D*. "It was great fun putting on the silly red and blue glasses and then watching dinosaurs, bugs and rockets jump out at you – like magic."

Bell is now a planetary scientist at Arizona State University. In this book, he weaves together his childhood love of 3D images with his expertise as one of the team leaders responsible for cameras on the NASA Mars rovers Spirit, Opportunity and Curiosity.

His book of 3D 'rover-eye views' of the Red Planet (red and blue glasses included) is a revised and expanded edition of an earlier version published in 2008. It's fantastic fun for kids and adults alike.

Five chapters outline the rover missions. One celebrates their amazing endurance on Mars, despite a daunting list of possible mishaps. You get a candid insider's view of the absorbing yet grinding day job of running of these projects and how dramatically the rovers have changed our picture of a distant world. But most of the book is devoted to stunning pictures.

Photos from spacecraft often give a flattened perspective, but these 3D Mars images pop out in a way that's jaw-dropping and sometimes so outlandish they make you giggle. There are awesome craggy craters, bumpy images of drill holes, techy rover selfies and bobbly 'blueberry fields' strewn with round pebbles. In the captions, Bell is meticulous about detailing the sizes of the features, essential for seeing them in context.

The scenes vividly bring home the ruggedness of Martian terrain – it's astonishing that the rovers can negotiate it at all.

★★★★★

HAZEL MUIR *is a freelance science writer*

Reader price £14.50, subscriber price £13.99
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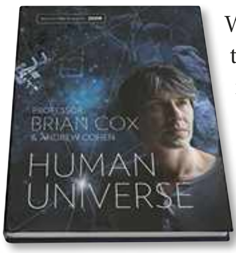
Human Universe

Brian Cox and Andrew Cohen
William Collins
£24.99 ● HB



We have learned that our planet is an inconsequential speck within a vast, dark and largely empty Universe and that our history is vanishingly brief on cosmic timescales. Does this underscore our insignificance or illustrate how remarkable we are?

Brian Cox's latest book, *Human Universe*, takes a refreshingly multi-disciplinary approach to this question and comes down firmly on the side of a wondrous humanity. The book, like the television series it accompanies, is structured around five big questions. After establishing where we are and whether we're likely to be alone, it asks how we became human, why we're here and what our future might hold. In search of answers, it delves into fundamental science, celebrates technological advances and draws on cutting-edge research in astronomy, biology, physics and archaeology.

Human Universe is, on the whole, a hugely engaging read. The pace is brisk and the tone is warmly conversational, enriched with candid personal reflections and a genuine and infectious enthusiasm for the subject. Written for an educated popular audience, some fascinating digressions – such as Kepler's study of snowflakes – add interest to sometimes familiar material. The volume is also lavishly produced, with thoughtfully sourced and beautifully reproduced illustrations throughout. There is perhaps a surfeit of photos of Cox looking thoughtful on location, however, and the story occasionally seems driven by the priorities of documentary film-making rather than by the underlying science.

Cox describes the book as "a love letter to humanity". In general, it's a good one.

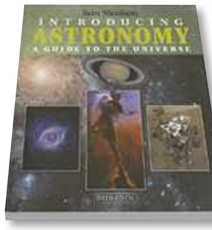
★★★★☆

OLIVIA JOHNSON *is an astronomer specialising in science education*

Reader price £20.99, subscriber price £19.99
P&P £1.99 Code: S0215/2 (until 25/03/15)

Introducing Astronomy
A Guide to the Universe

Iain Nicolson
Dunedin
£9.99 ● PB



Writing an introduction to astronomy can be a daunting task when you consider the sheer volume of information available, but Iain Nicolson has done it well. *Introducing Astronomy: A Guide to the Universe* is written in an accessible style that takes the reader on a journey of discovery through the most important aspects of both.

The guidebook begins with our place in space and how the sky changes over time, before moving on to cover the Solar System. Nicolson explores star birth, life and death, and explains intricate and complex subjects such as black holes, stellar spectra, the basics of galaxies and dark matter with ease.

Towards the end of the book there is an examination of the relatively new field of exoplanets and how life may have formed, and a final chapter that discusses astronomy kit. Here, he briefly summarises the basics of telescope design and light gathering capability before touching on robotic exploration, such as that performed by Curiosity on Mars, and what CCD imaging reveals about the Universe.

The choice of images is impressive, while the many charts and diagrams – clear and informative without being over complex or cluttered – add to the book's usefulness. Overall, it achieves what it sets out to do. This concise introduction to astronomy would make a great gift for those developing an interest in the night sky.

★★★★☆

PAUL MONEY *is* BBC Sky at Night Magazine's *reviews editor*

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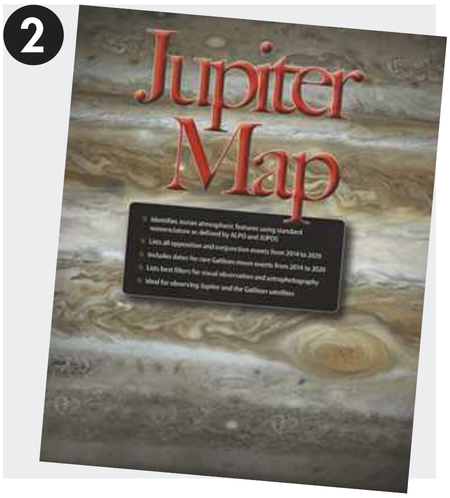
Gear

Elizabeth Pearson rounds up the latest astronomical accessories



1 Fujiyama Series HD Eyepieces

Price £89.94 • **Supplier** 365 Astronomy
020 3384 5187 • www.365astronomy.com

These high-definition orthoscopic eyepieces are blackened internally to reduce reflections and are intended for planetary use. Focal lengths 4mm-25mm available; 18mm shown.

2 Orion Jupiter Map and Observing Guide

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Ideal for back-garden observers, this fold-out guide includes a detailed map of the gas giant, plus a list of observable conjunctions, oppositions and Jovian moon events until 2020.

3 First Contact Cleaning Starter Kit

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Safely remove dust, grease and fingerprints from your optics with this kit. The cleaning agent is available in two variants: clear for everyday use and red for cleaning prior to storage.

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5 Faux Real Child's NASA Space T-shirt

Price £20 • **Supplier** Science Museum
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The perfect outfit for little astronauts in training, this T-shirt is designed to look like a real spacesuit, complete with badges and fabric folds.

6 MaxIm DL Version 6 Basic

Price $199 • **Supplier** Diffraction Limited
001 613 225 2732 • www.cyanogen.com

The MaxIm DL software package gives you extensive equipment control and image processing options in one easy download.

WHAT I REALLY WANT TO KNOW IS…

What causes Venus's dark spots?

Elise Harrington is trying to get on top of why the second planet from the Sun could have metallic frost on its peaks

INTERVIEWED BY PAUL SUTHERLAND

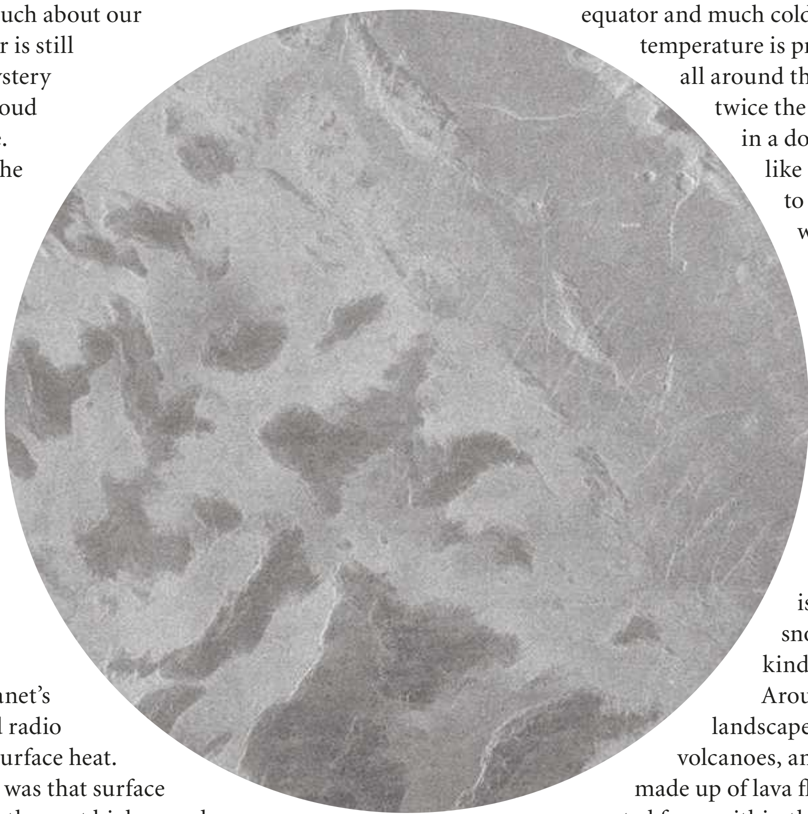
Venus is one of the closest planets to Earth. But much about our inner neighbour is still shrouded in mystery thanks to the permanent cloud cover that masks its surface.

We began to learn what the surface of Venus was like in the last century, thanks to radar observations from Earth and then visits by space probes. They told us it is an inhospitable place, with crushing air pressure, searing temperatures and a poisonous, sulphurous atmosphere.

A NASA spacecraft called Magellan orbited Venus from 1990 to 1994. It made extensive radar observations to map the planet's landscape, plus it measured radio emissions given off by the surface heat. One thing that was noticed was that surface features became brighter as they got higher, and a number of theories have been put forward to explain why this might be so. A handful of dark spots were also noticed at the highest elevations, which left scientists baffled.

An error? Unlikely

We used modern techniques to analyse two areas in the Ovda Regio highlands region of Venus in higher spatial resolution to try to explain why they were bright. For the most part, our data showed the same brightening with elevation that previous scientists had found, up to about 4,500m. But we noticed that at the highest elevations, above 4,700m, it was suddenly dropping off. Instead of getting brighter as we expected, there was a sudden sharp drop to lower levels, like those seen in the lowlands, showing radio waves were not being reflected. And to our surprise, whereas the early studies showed just a few dark spots, we were seeing a couple of hundred of them. This told us that these were real features on Venus, and not just random errors in the data.



The dark patches and bright features amid the Ovda Regio; could they be caused by an as yet unseen 'frost'?

THE GEOLOGICAL SOCIETY OF AMERICA/ELISE HARRINGTON/SIMON FRASER UNIV. (LPI UNDERGRADUATE INTERN)/ALLAN TREIMAN/LPI

ABOUT ELISE HARRINGTON

Elise Harrington is a researcher in the Department of Earth Sciences at Simon Fraser University in Canada. She took a fresh look at Magellan's data while working with Dr Allan Treiman at the Lunar and Planetary Institute.

Venus isn't like Earth, where it is hot at the equator and much colder at the poles. The temperature is pretty much the same all around the planet, more than twice the maximum temperature in a domestic oven. But just like on Earth, if you were to climb a mountain it would begin to get cooler. So we think the dark spots are like our own mountaintops, where you reach a snowline and see snow above but not below. Instead of snow, we suggest that some kind of metallic compound produced by Venus's extraordinary conditions is falling, like rain or snow, to form a strange kind of frost.

Around four per cent of Venus's landscape is covered in active volcanoes, and almost all its surface is made up of lava flows and magma that has erupted from within the planet. So it is a very basaltic, igneous world. What we are trying to find out is what sort of minerals could be present to be producing such unique chemical signatures. Some sort of insight into the composition of the lava that is erupting from those volcanoes would be very useful information to help our research.

So how do we find out what is there? Another space probe would be awesome. Europe's recent visitor, Venus Express, has not been able to help us because it has been mainly studying the planet's atmosphere.

The data from NASA's Magellan probe had a spatial resolution of 75m: in other words, one pixel in an image represented an area 75m across. That's great in terms of Venus research because it was hugely better than had been managed by previous, older spacecraft. But probes imaging the Moon have managed to get down to a resolution of 30cm.

It would be great to look at Venus in similar detail. That could help solve the riddle of the dark spots and tell us a lot more besides. We simply need to go back to Venus.

UK Retailer Guide

Find the right one for you: buy your telescope from a specialist retailer

It is quite easy to become daunted by the vast array of equipment that is available to today's amateur astronomers. Different makes, different models, different sizes and optical arrangements – if you're new to the hobby, how do you make sense of all these details and find the telescope that will show you the Universe?

The answer lies in buying from a specialist retailer – somewhere that really knows what they're talking about. Like the retailers in this guide, they'll have the practical knowledge that will guide you towards the scope that won't end up gathering dust in a cupboard.

Today there are over 1,000 models of telescope to choose from – refractors and reflectors, Dobsonians and Newtonians, Schmidt- and Maksutov-Cassegrains. And just as important as the telescope is the mount it sits on; but do you go for equatorial or altazimuth, manual or Go-To? And what about accessories like eyepieces and finderscopes?

That's certainly a lot to consider before making a decision, but a specialist retailer will help you make that decision, taking important considerations like portability, construction and price into account.

So if you need friendly, face-to-face advice and excellent aftersales service, free from biased opinions, specialist telescope retailers are the place to go for a helping hand through the technical literature and tables of figures. They'll help you find a scope that combines quality and convenience at a price that's right.

TELESCOPE HOUSE

Founded in 1785, Telescope House has been responsible for supplying many well-known Astronomers with telescopes and equipment. The late Sir Patrick Moore bought the majority of his telescopes from the company, including his very first instrument. With a friendly showroom in Surrey, a number one ranked retail website and a service centre with fully qualified staff, the company offers equipment from manufacturers such as Meade, Revelation, Coronado, Bresser, Skywatcher, Orion USA, TeleVue, Vixen and Explore Scientific. Whether it's advice on your first telescope, to setting up advanced Astrophotography systems, the staff at Telescope House have a wealth of experience and instant access to the right stock to back it up.

Telescope House
Broadhurst Clarkson & Fuller Ltd. - Established 1785

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TRING ASTRONOMY CENTRE

At Tring Astronomy Centre we know that choosing the right equipment can be a minefield, but we strongly believe that seeing telescopes in the flesh and talking to an expert in a relaxed environment can really help. That's why we have a coffee machine, a fully stocked bicuit barrel, and 45+ telescopes on display. As well as representing leading brands such as Celestron, Sky-Watcher, Baader Planetarium, Altair Astro, Vixen, Opticron, AstroTrac, iOptron, Lunt, Starlight Instruments, ZW Optical and many more we also offer a hire service so you can even try before you buy! So what are you waiting for? Visit or contact Tring Astronomy Centre and lets talk Astronomy!

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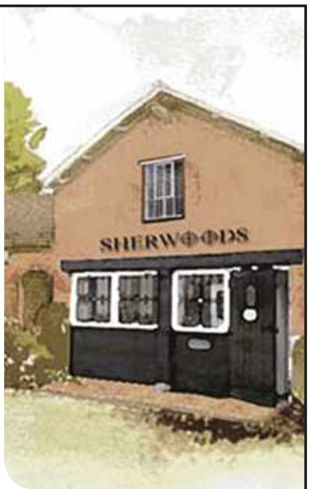
SHERWOODS



Established for over 60 years, we at Sherwoods are one of the Midlands leading suppliers of astronomical telescopes, binoculars and accessories. Through our website and showroom we are able to supply optics from some of the world's leading optical manufacturers including Celestron, Skywatcher and Meade at some of the lowest prices in the UK. We offer a full mail-order service including next day delivery on many items held in stock.

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THE WIDESCREEN CENTRE

The Widescreen Centre is London's Astronomy Showroom, located in Sherlock Holmes territory off Baker Street in the heart of Marylebone - a family owned and run business since starting out in1971. Our experienced and highly knowledgeable staff will offer you quality, choice, expertise and service - see Celestron, Sky-Watcher, Meade, Orion, Tele Vue, APM, Takahashi and much, much more besides says Simon Bennett, Widescreen's MD and lifelong amateur astronomer, "If the correct equipment is purchased it will give a lifetime's enjoyment. This is our mission. We will never sell you anything you don't need" Watch out for Widescreen at Star Parties and exhibitions throughout the UK.

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Green Witch is one of the UK's leading suppliers of telescopes, binoculars and accessories for astronomy. Founded by former members of the Royal Greenwich Observatory in 1998, Green Witch is dedicated to helping you choose and use the equipment that is right for you.

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The Southern Hemisphere in February

With Glenn Dawes

WHEN TO USE THIS CHART

1 FEB AT 00:00 UT
15 FEB AT 23:00 UT
28 FEB AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

FEBRUARY HIGHLIGHTS

The Alpha Centaurid meteor shower is active from 28 January to 21 February, with maximum activity expected on the 8th. The shower is known for brightly coloured fireballs and some surprisingly strong peaks.

Watch Mercury's changing phases. It starts the month with a 'new' phase and is hard to see in the morning twilight, but grows to a 50% lit 'first quarter' appearance by the end of the month.

STARS AND CONSTELLATIONS

For the next four months, Jupiter will be the only obvious marker to the constellation of Cancer, the Crab. This obscure member of the zodiac is well placed in the northern evening sky, nestled between Gemini to the west and Leo to the east. The Crab's most obvious feature is the Beehive Cluster, M44. Also known as Praesepe or the Manger, M44 has two 4th-magnitude stars, Asellus Australis and Asellus Borealis – that is, the southern and northern asses (donkeys).

THE PLANETS

Search low in the early western evening sky to discover brilliant Venus and nearby Mars, both setting around the end of twilight. Jupiter is at opposition and up the whole night. Saturn rises around midnight, as Jupiter crosses the meridian, but is best observed in the early hours. Having stayed up so late, you may as well wait for Mercury, which rises out of the Sun's glow and is at its best for morning observations from mid-February to mid-March.

DEEP-SKY OBJECTS

The naked-eye Beehive Cluster in Cancer, M44 (RA 8h 40.4m, dec. +19° 40'; pictured) is a brilliant binocular object. Covering 1° of sky, its brightest members consist of around a dozen 6th- to 8th-magnitude stars, including three arranged in an obvious isosceles triangle just southeast of centre. The 6th-magnitude stars 39 and 40 Cancri make an attractive pair, while a small telescope reveals over 100 stars.

Cancer has another deep-sky object of note, star cluster M67 (RA 8h 51.3m, dec. +11° 48'). Located 8° south-southeast of M44, this open cluster is 25 arcminutes across, with its brightest members arranged in loose groups interspersed with arcs. It contains around 100 stars from 9th to 14th magnitude.

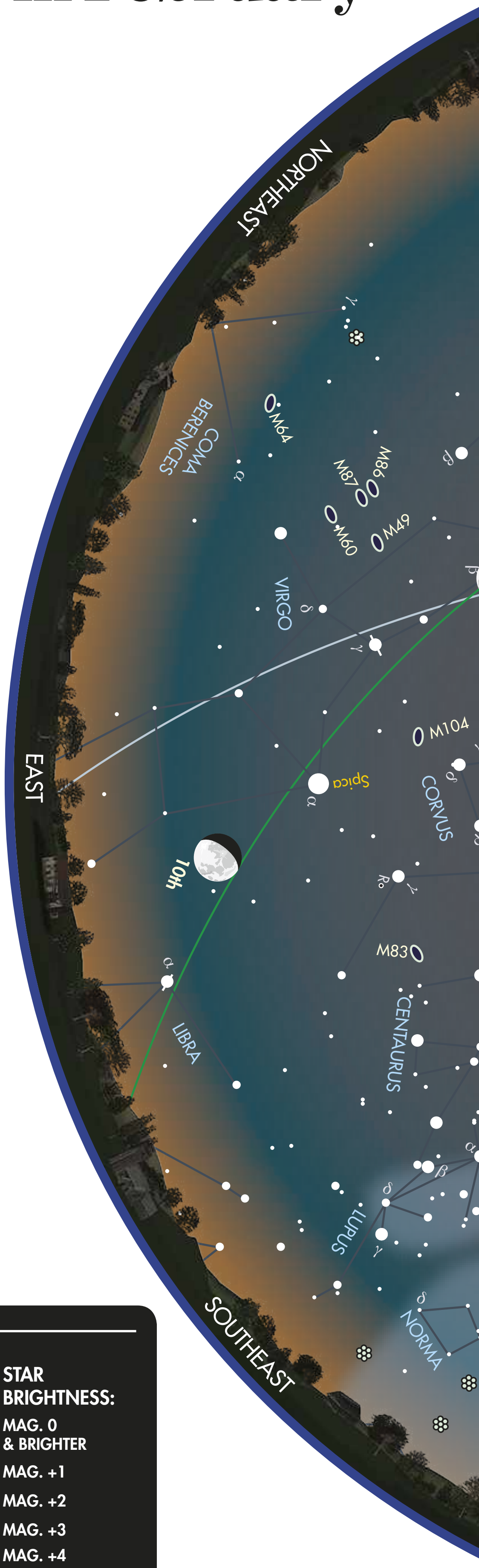
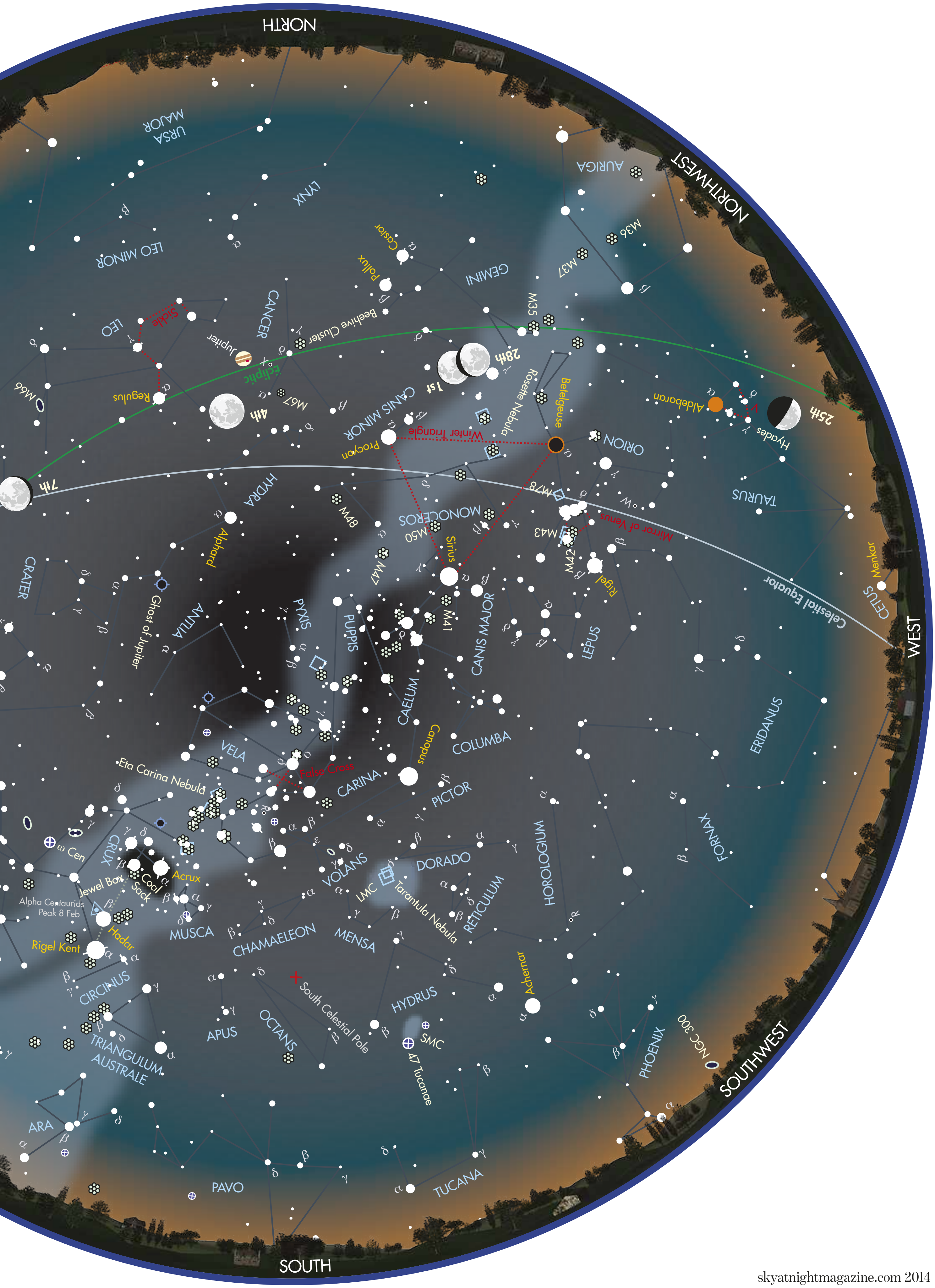


CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

THINKSTOCK


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
LYNX
LEO MINOR
LEO
Sickle
Regulus
M66
Jupiter
CANCER
Beehive Cluster
M67
4th
Castor
Pollux
GEMINI
M35
M37
M36
AURIGA
28th
1st
CANIS MINOR
Procyon
Winter Triangle
Rosette Nebula
Betelgeuse
ORION
Aldebaran
Hyades
25th
TAURUS
ecliptic
7th
Celestial Equator
Mirror of Venus
M78
M43
M42
Rigel
MONOCEROS
M50
M48
M47
M46
Sirius
M41
CANIS MAJOR
LEPUS
CETUS
Menkar
ERIDANUS
HYDRA
Alphard
CRATER
Ghost of Jupiter
ANTLIA
PYXIS
PUPPIS
CAELUM
COLUMBA
Canopus
VELA
Eta Carina Nebula
False Cross
CARINA
PICTOR
DORADO
HOROLOGIUM
FORNAX
RETICULUM
Tarantula Nebula
LMC
VOLANS
ω Cen
CRUX
Acrux
Coal Sack
Jewel Box
Alpha Centaurids
Peak 8 Feb
Hadar
Rigel Kent
MUSCA
CHAMAELEON
MENSA
CIRCINUS
TRIANGULUM AUSTRALE
APUS
OCTANS
South Celestial Pole
HYDRUS
SMC
47 Tucanae
Achernar
PHOENIX
NGC 300
ARA
PAVO
TUCANA